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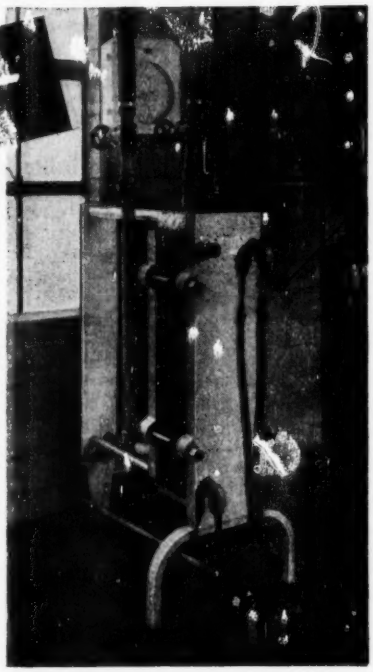

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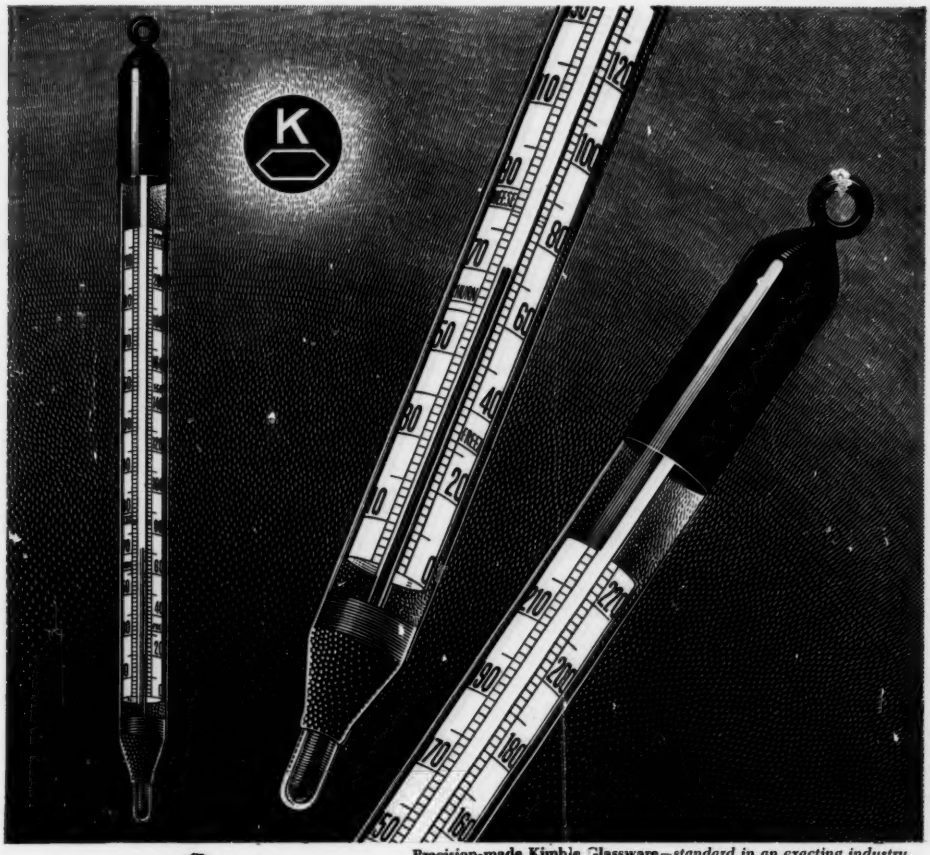

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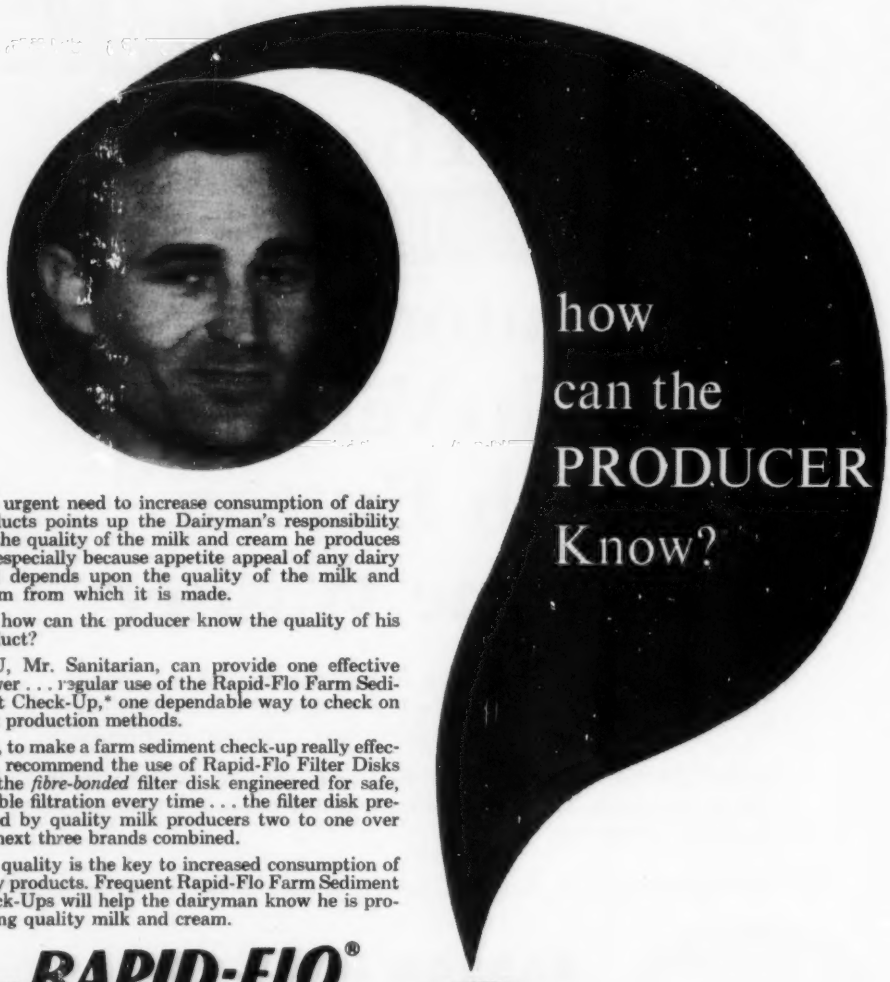

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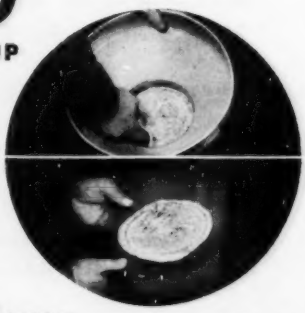

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JOURNAL OF DAIRY SCIENCE

VOLUME XXXVIII JANUARY, 1955 NUMBER 1

EFFECTS OF ADDING SMALL QUANTITIES OF AUREOMYCIN (AUROFAC) TO THE STARTER OF CALVES

W. S. GAUNYA, R. D. MOCHRIE,[1] R. E. JOHNSON, AND CECILIA M. DEMBICZAK

Animal Industries Department, University of Connecticut, Storrs

Small quantities of aureomycin when added to the ration of young dairy calves have resulted in increased growth. This was probably due to a greater nutrient intake, although in some investigations the increased rate of growth has been attributed to decreased incidence of scours. The aureomycin was fed in a variety of forms and at various levels under many systems of calf raising *(1, 5)*. In 1952, Mochrie *et al. (2)* of this station incorporated aureomycin (Aurofac[2]) into a calf starter used in a limited whole milk feeding system at levels from 9 to 54 mg. per pound of starter. The calves in the aureomycin-supplemented groups gained slightly more (5%) than the unsupplemented group. In order to test whether lower levels of aureomycin than those fed in the previous experiment would be as effective in eliciting a growth response, the present experiment was undertaken.

EXPERIMENTAL PROCEDURE

This experiment was a randomized block design with each block consisting of three levels of aureomycin supplementation within blocks. Within blocks there was uniformity of breed, sex, and housing. There were 24 calves, including 9 Guernsey males, 6 Guernsey females, 6 Holstein females, and 3 Holstein males. After Sept. 20, 1952, calves born in the University herd were randomly assigned to one of three positions within their current breed-sex block. Four blocks were housed in individual solid-walled pens and four in large pens in which the calves were chained to their mangers.

TABLE 1

Calf feeding schedule (lb/day)

Days of age	Milk		Max. starter		Hay	Water
	Holst.	Guern.	Holst.	Guern.		
2-7	8	7	0	0	0	0
8-14	7	6	4	3	ad lib	ad lib
15-21	5	5	4	3	"	"
22-28	4	4	4	3	"	"
29-35	2	2	4	3	"	"
36-91	0	0	4	3	"	"

Received for publication July 13, 1954.

[1] Present address: Animal Industry Department, North Carolina State College, Raleigh.

[2] Lederle Feed Supplement Aurofac contains not less than 1.8 g. aureomycin and 1.8 mg. of vitamin B_{12} per pound.

All calves were removed from their dams 18 to 24 hours after birth and placed in their assigned stalls. They were fed according to the schedule in Table 1. The starter was composed of 400 lb. cracked yellow corn, 400 lb. crimped oats, 300 lb. wheat bran, 148.75 lb. linseed oil meal, 280 lb. soybean oil meal, 200 lb. alfalfa leaf meal, 150 lb. dried skimmilk, 100 lb. molasses, 40 lb. Forta Feed–Lederle 2-20, 1.25 lb. irradiated yeast, 20 lb. dicalcium phosphate, and 10 lb. iodized salt. The starter was custom mixed and had an average proximate composition on a dry matter basis as follows: crude protein 21.09%, ether extract 4.24%, fiber 8.04%, ash 7.16%, and nitrogen free extract 59.46%. The hay fed graded U. S. No. 1 timothy-clover mixed, averaging 63.7% green color, and 4.12% foreign material. It was chopped at a setting of ¼ in. The average proximate composition of the hay was: crude protein 12.00%, ether extract 3.33%, fiber 25.95%, ash 6.42%, and nitrogen free extract 48.67% on a dry matter basis.

The starter to which no aureomycin supplement was added was designated as the zero level starter. The 2.5 and 5.0 level starters were supplemented with 2.5 and 5.0 lb. of Aurofac 2A [3] per ton and were assumed to contain 4.5 and 9.0 mg. aureomycin per pound of starter, respectively.

The calves were weighed on the seventh day of age and every seventh day thereafter through the 91st day. Height at withers, heart girth, and barrel circumference measurements were taken on the seventh day of age and every 14th day thereafter through the 91st day. Weights and measurements were taken within a range of 1 hour from day to day, and, insofar as possible, by the same person. Weekly feed intakes were determined. Twice daily observations for scours were made, with rectal temperatures being taken when calves showed evidence of scours. Calves with a rectal temperature of 103° F. or more were treated as follows: initial treatment, 1 ml. 25% sodium sulfamethazine solution intravenously for every 3.8 lb. of body weight; subsequent treatments, one 2.5 g. oblet of sulfamethazine for every 80 lb. of body weight, starting 12 hours after the initial treatment and repeated every 12 hours thereafter for 48 hours.

The various criteria were compared among groups at 7 to 49 days and 7 to 91 days in an effort to determine if there was an early response which was not apparent at 91 days (Tables 2 and 3). The data were analyzed by the analysis of variance and covariance *(4)* and they were, in the case of gains in weight, feed consumption, and feed utilization, adjusted for body weight at 7 days when this factor significantly ($P < 0.05$) influenced 49- and 91-day observations. Similarly, height at withers, heart girth, and barrel circumference at 49 and 91 days were adjusted for their respective 7-day measurements when significantly influenced by them.

RESULTS AND DISCUSSION

Growth. Weight at 7 days significantly influenced total gains from 7 through 49 and 91 days; however, there was no significant difference among treatments from 7 through either 49 or 91 days of age.

[3] Lederle Feed Supplement Aurofac 2A contains not less than 3.6 g. aureomycin per pound.

TABLE 2
Mean growth data of calves fed three levels of aureomycin

Criterion	Aurofac 2A per ton of starter			Standard deviation of the calf
	0.0 lb.	2.5 lb.	5.0 lb.	
Weight at 7 days *(lb.)*	84.91	75.69	82.09	5.37
Gain 7-49 days *(lb.)*	42.69	44.81	46.72	10.72
Adj. gain 7-49 days *(lb.)*	46.06	40.44	47.72	9.86
Gain 7-91 days *(lb.)*	108.03	110.13	108.25	12.88
Adj. gains 7-91 days *(lb.)*	111.77	105.27	109.37	12.33
Height at withers at 7 days *(in.)*	29.28	28.41	28.94	0.34
Height at withers at 49 days *(in.)*	31.23	30.56	31.28	0.96
Adj. height at withers at 49 days *(in.)*	31.00	30.82	31.25	0.67
Height at withers at 91 days *(in.)*	34.06	33.81	33.97	0.81
Adj. height at withers at 91 days *(in.)*	33.87	34.04	33.94	0.55
Hearth girth at 7 days *(in.)*	28.03	26.94	28.12	0.54
Heart girth at 49 days *(in.)*	32.48	31.34	32.15	1.04
Heart girth at 91 days *(in.)*	36.84	36.69	37.06	1.01
Barrel circumference at 7 days *(in.)*	29.06	28.34	29.22	0.79
Barrel circumference at 49 days *(in.)*	40.57	39.16	41.03	2.08
Barrel circumference at 91 days *(in.)*	48.88	48.06	48.94	2.35

Adjustment for 7-day values did not significantly reduce variability in either heart girth or barrel circumference values at 49 or 91 days. Differences among groups were not significant.

Although height at withers at 7 days significantly influenced height at 49 and 91 days, the adjusted data showed no significant differences among levels in regard to this criterion.

Feed consumption. The amount of starter consumed through 49 or 91 days was not significantly different among treatments. No significant reduction in variability occurred when adjustment for 7-day live weight was made.

Hay consumption through 49 days was not significantly influenced by body weight at 7 days nor was hay consumption through 49 days significantly different among levels. Hay consumption through 91 days was significantly influenced by

TABLE 3
Feed consumption and scours data of calves fed three levels of aureomycin

	Aurofac 2A per ton of starter			Standard deviation of the calf
	0.0 lb.	2.5 lb.	5.0 lb.	
Av. starter consumption to 49 days *(lb.)*	78.35	79.13	74.16	16.85
Av. starter consumption to 91 days *(lb.)*	220.1	221.5	216.3	17.12
Av. hay consumption to 49 days *(lb.)*	7.8	6.2	8.1	6.2
Av. hay consumption to 91 days *(lb.)*	81.3	71.1	70.7	21.4
Av. adj. hay consumption to 91 days *(lb.)*	88.9[a]	61.3	72.9	18.2
Av. TDN consumption to 49 days *(lb.)*	61.34	60.92	59.19	10.34
Av. TDN consumption to 91 days *(lb.)*	206.53	201.12	198.63	18.19
Av. adj. TDN consumption to 91 days *(lb.)*	212.26	193.67	200.34	16.73
Av. TDN per lb. of gain 7-49 days *(lb.)*	1.46	1.38	1.27	0.14
Av. adj. TDN per lb. of gain 7-49 days *(lb.)*	1.41	1.45	1.26[b]	0.12
Av. TDN per lb. gain 7-91 days *(lb.)*	1.91	1.84	1.84	0.09
Total scour days	102	31	93	
Av. cases of scours	1.25	0.63	1.00	

[a] $P < 0.05$; 0 vs. 2.5 and 5.0.
[b] $P < 0.01$; 5.0 vs. 0 and 2.5.

weight at 7 days. The control calves consumed significantly more hay ($P < 0.05$) than did the aureomycin supplemented calves when hay intake was adjusted for body weight at 7 days.

The TDN consumption was estimated according to the method of Schneider *et al. (3)*. TDN consumption through 49 days was not influenced by weight at 7 days nor was TDN intake among levels of aureomycin significantly different. TDN consumption through 91 days was significantly influenced by weight at 7 days; and the average TDN intake for the control calves was somewhat, although not significantly, higher than the aureomycin calves ($P < 0.10$).

The efficiency of gain is expressed as pounds TDN consumed per pound of gain in body weight. The efficiency of gain from 7 through 49 days was significantly influenced by weight at 7 days. When adjusted for weight at 7 days, the efficiency of gain was highly significantly greater ($P < 0.01$) in the group which received the starter containing 5.0 lb. of Aurofac 2A supplement. The efficiency of gain from 7 through 91 days was not influenced by weight at 7 days, nor was there any difference among levels of Aurofac 2A.

Scours. In this trial, there was a rather high incidence of scours, although not of serious nature. The incidence of scours expressed as total scour days was 102, 31, and 93 for the 0, 2.5, and 5.0 levels, respectively (Table 3). There was a case of chronic scours in both the 0 and 5.0-lb. levels, accounting for the high number of scour days in those levels. There were ten, five, and eight cases of scours in the 0, 2.5, and 5.0 lb. levels, respectively; and 10, 5, and 10 treatments, respectively. There was no mortality and little loss of appetite as a result of scours. The per cent of scour-free days per calf was converted to angles *(4)* and subjected to analysis of variance, which showed no significant difference among levels. Analysis of the square roots of the number of treatments per calf failed to reveal any difference among levels.

The results of this experiment indicate that small quantities of aureomycin added to the starter of calves which were fed limited quantities of whole milk and starter failed to promote growth or reduce the incidence of scours. Aureomycin was not fed until the eighth day and then in quantities proportional to the starter consumed. Also, starter intake was limited and the aureomycin had little opportunity to stimulate starter intake. Aureomycin, in this case, did not stimulate hay intake, the control calves consuming significantly more hay than the aureomycin calves. The addition of small quantities of aureomycin to the starter of calves raised under such a limited whole milk and starter system does not appear to be of great value.

SUMMARY

Twenty-four Guernsey and Holstein calves raised under a limited whole milk system were assigned to one of three starters supplemented with 0, 2.5, and 5.0 lb. of Aurofac 2A per ton. Starter intake was limited to 3 and 4 lb. daily for Guernseys and Holsteins, respectively. Chopped timothy-clover hay was fed ad lib. There were no significant differences among levels in regard to the following

growth criteria at either 49 or 91 days of age: gain in weight, increase in height at withers, heart girth, or barrel circumference. Starter consumption was not different among levels at 49 or 91 days. The 0-level calves consumed significantly more hay and somewhat more TDN through 91 days than did the aureomycin calves. Efficiency of gain was significantly higher from 7 through 49 days of age for the calves receiving starter containing 5 lb. Aurofac 2A per ton, but this greater efficiency did not persist when the data through 91 days of age were considered. The presence of aureomycin in the starter did not significantly influence the incidence of scours.

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REFERENCES

(1) Knodt, C. B. Antibiotics in the Growth of Ruminant Animals. *Antibiotics and Chemotherapy*, 3: 442. 1953.

(2) Mochrie, R. D., Dolge, K. L., Eaton, H. D., and Elliott, F. I. Effect of Adding Various Levels of Aureomycin Supplement to Starter on Growth and Blood Constituents of Guernsey Calves. Storrs Agr. Expt. Sta., *Inf. Bull.* 48. 1953.

(3) Schneider, B. H., Lucas, H. L., Cipolloni, Mary A., and Pavlech, Helen M. The Prediction of Digestibility for Feeds for Which There Are Only Proximate Composition Data. *J. Animal Sci.*, 11: 77. 1952.

(4) Snedecor, G. W. *Statistical Methods.* 4th ed. Iowa State College Press, Ames. 1946.

(5) Warner, R. G. Recent Findings on Antibiotics and Surfactants for Ruminants. *Proc. Cornell Nutrition Conf.*, p. 126. 1952.

THE RELATION OF GROWTH, FEED CONSUMPTION, AND CERTAIN BLOOD CONSTITUENTS TO CHANGES IN THE DIETARY OF YOUNG DAIRY CALVES[1,2]

M. R. LAMBERT, N. L. JACOBSON, R. S. ALLEN, AND M. R. BELL
Department of Animal Husbandry, Iowa Agricultural Experiment Station, Ames

The popularity in recent years of limited whole milk and milk replacement feeding plans has increased the significance of highly palatable, economical, and nutritionally adequate calf starters. Furthermore, research on calf nutrition problems has focused attention on the levels of various blood components, since the latter often serve as valuable criteria in evaluating nutritional adequacy of the diet. The concentrations of carotenoids and vitamin A in blood plasma or serum *(10, 20)* and of fat in the blood plasma *(3, 8)* of young calves are closely related to changes in the types of feed consumed. Moreover, the early postnatal decline in blood glucose levels of young ruminants probably is associated with age and/or diet *(7, 9, 12)*.

The objectives of the present study were twofold: *(a)* to explore the gross responses of young dairy calves on a limited whole milk feeding plan to various calf starters and *(b)* to study the interrelationships among several dietary and blood components of the calves.

EXPERIMENTAL PROCEDURE

Fifty-four young calves, 36 Holsteins, 6 Brown Swiss, 6 Ayrshires, and 6 Jerseys, were divided into six comparable groups of nine animals each. Approximately equal numbers of each sex were employed. All calves were allowed to remain with their respective dams for 3 days postpartum and then were removed to individual calf pens bedded with wood shavings. During the subsequent experimental period of 116 days, the calves were maintained in individual pens, had free access to water, and were fed good quality hay ad libitum and a calf starter that was limited to a maximum of 4 lb. daily per calf. Whole milk, approximately 3.4% fat, was fed during the first 7 weeks at the following daily rates in pounds per 100 lb. initial (4-day) weight: 8, 9, 10, 9, 7, 6, and 4, respectively. The diets fed to the respective groups differed only in the composition of the calf starter (Table 1), varying from simple (No. 1) to relatively complex (No. 6).

The calves were examined just prior to the evening and morning feedings for symptoms of diarrhea and other abnormalities. Milk, hay, and concentrate consumptions were recorded. At the beginning of the experimental period, and

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[2] Research supported in part through funds provided by Western Condensing Co., Appleton, Wis.

TABLE 1
Composition of calf starters

Ingredient	Starter					
	1	2	3	4	5	6
			(%)			
Corn (coarse ground)	40.0	37.0	34.0	30.0	30.0	16.5
Oats (crushed)	30.0	27.5	25.5	22.5	22.5	20.0
Soybean oil meal (expeller)	28.0	26.5	24.5	21.5	21.5	17.0
Steamed bone meal	1.0	1.0	1.0	1.0	1.0	1.0
Salt (NaCl)[a]	1.0	0.5	—	—	—	0.5
Dried whey product[b]	—	7.5	15.0	25.0	—	10.0
Corn molasses product[c]	—	—	—	—	25.0	—
Wheat bran	—	—	—	—	—	15.0
Linseed oil meal	—	—	—	—	—	10.0
Molasses (blackstrap)	—	—	—	—	—	5.0
Dehydrated alfalfa meal	—	—	—	—	—	5.0

[a] Amount of salt was varied because of differences in NaCl content of other ingredients.
[b] Analysis: protein, 17.7%; nitrogen-free extract, 57.5%; ether extract, 0.9%; ash, 12.8%; and moisture, 11.1%. This product was provided by Western Condensing Company, Appleton, Wis.
[c] Analysis: protein, 16.5%; reducing sugar, 10.8%; total sugar, 14.4%; and moisture, 7.0%. This product, made from hydrol, corn gluten meal and corn oil meal, was provided by Clinton Foods, Inc., Clinton, Iowa.

at weekly intervals thereafter, calves were weighed and samples of venous blood were obtained. The anticoagulant employed in the blood samples was a mixture of potassium oxalate and sodium fluoride, the latter serving to prevent glycolysis *(15)*. An aliquot of each whole blood sample was analyzed for reducing sugar by the colorimetric method of Somogyi *(14)*. The remainder was centrifuged and the plasma was analyzed for fat by the method of Allen *(1)* and for vitamin A and carotenoids by the saponification method of Allen *et al. (2)*.

RESULTS AND DISCUSSION

The mean daily weight gains of calves in the various groups are shown in Figure 1. Birth weights were not considered in the random selection of calves for the respective groups; for this reason the mean starting weights were variable. Calves in Group IV had the highest mean starting weight (85.4 lb.); those in Group III the lowest (76.3 lb.). The mean weight gains of the groups during the experimental period were similar with the exception of Group IV.

The mean feed consumption for calves in the various groups is shown in Table 2. Calves in Group IV (highest initial mean weight) consumed less starter than calves in other groups. The high content of whey in the starter (25%) received by calves in Group IV may have been associated with the apparent reduced palatability, since this starter contained a high percentage of extremely fine particles. Calves in Group VI consumed the most hay and starter, but this difference did not result in correspondingly greater weight gains. There was no apparent advantage in feeding a "complex" calf starter compared to a simple concentrate mixture, which is in agreement with the findings of Hibbs *et al. (6)* and Gardner *(5)*. It appeared that rumen function was sufficiently developed in

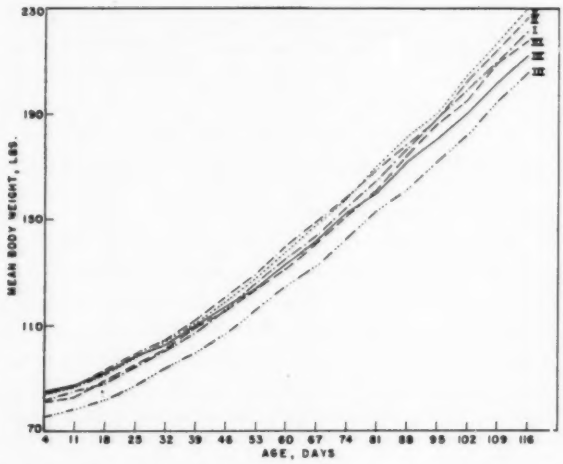

FIG. 1. Effect of various calf starters on changes in mean body weights of dairy calves.

most calves by 7 weeks of age to allow the removal of milk from the ration without a decrease in rate of growth.

Hay and starter consumption of the 36 Holstein calves on the experiment is shown in Figure 2. Alfalfa hay was fed free choice and starter was fed ad libitum up to a maximum of 4 lb. per day. Hay consumption did not exceed starter consumption until late in the experiment, when the amount of starter consumed was limited by the maximum daily allowance.

Despite the reduced growth rate of calves in Group IV, the differences among groups were not significant when the data were subjected to an analysis of variance *(13)*. Moreover, there were no statistically significant differences among groups in the incidence of diarrhea, or in any of the blood constituents determined. Even though Starter 6 contained 5% dehydrated alfalfa meal, the mean blood plasma carotenoid and vitamin A values for these calves did not differ appreciably from those of calves in other groups. It seemed desirable, therefore,

TABLE 2

Mean feed consumption for calves in the various groups

Group	Whole milk	Alfalfa hay	Starter
	(lb.)	*(lb.)*	*(lb.)*
I	302.6	182.8	267.1
II	308.2	168.4	269.6
III	280.0	136.6	271.5
IV	313.1	179.3	243.5
V	303.1	192.9	267.3
VI	293.8	193.8	287.9
Av. per calf	300.1	175.6	267.8
Daily av. per calf	6.1[a]	1.6	2.4

[a] Based on the 7-week milk feeding period.

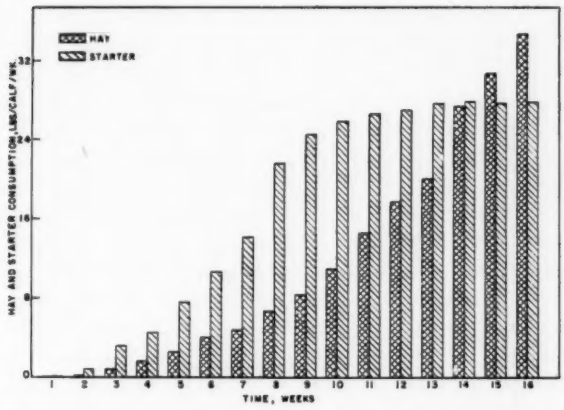

FIG. 2. Mean hay and starter consumption for the 36 Holstein calves. (Starter intake was limited to a maximum daily intake of 4 lb. per calf).

to combine the hematologic data of the various groups to obtain means which might be considered typical under the conditions of this experiment.

The interrelationships between calculated lipid intake and plasma fat, carotenoids, and vitamin A are shown in Figure 3. Blood plasma fat levels remained essentially constant during the first week but subsequently increased sharply, attaining the maximum value of 168 mg. per 100 ml. blood plasma by the fourth week. The change thereafter was downward, reaching the minimum level (113 mg. per 100 ml.) by the ninth week. This was followed by higher but irregular values. The close correlation of blood plasma fat levels with dietary fat intake is in agreement with data of Allen *(1)* and Barker *et al. (3)*.

Plasma carotenoids decreased during the initial 3 weeks to less than 15γ per 100 ml. but subsequently increased at a rapid rate to 60γ per 100 ml. by the end of the experimental period. These changes are slightly different from those of Wise *et al. (20)*, who reported that although good quality hay was accessible to the calves after 2 weeks of age, the animals were 5 to 6 weeks of age before the intake of carotenoids from this source was sufficient to increase the carotenoid content of the blood. This difference may be due to quality of hay, to age at which the calves began eating hay, to individual differences of the experimental animals, or to a combination thereof.

Blood plasma vitamin A levels decreased to about 11γ per 100 ml. during the last 3 weeks of the milk feeding period. If 10γ of vitamin A per 100 ml. of plasma is accepted as the lower level of the normal range of concentrations *(4)*, this average minimum value during the present experiment is within the normal range. Several individuals, however, exhibited levels below 10γ. The elimination of milk from the diet resulted in a prompt and consistent increase in the plasma vitamin A concentration. It seems doubtful that this increase can be attributed to an increase, if any, in the amount of vitamin A activity ingested. This phe-

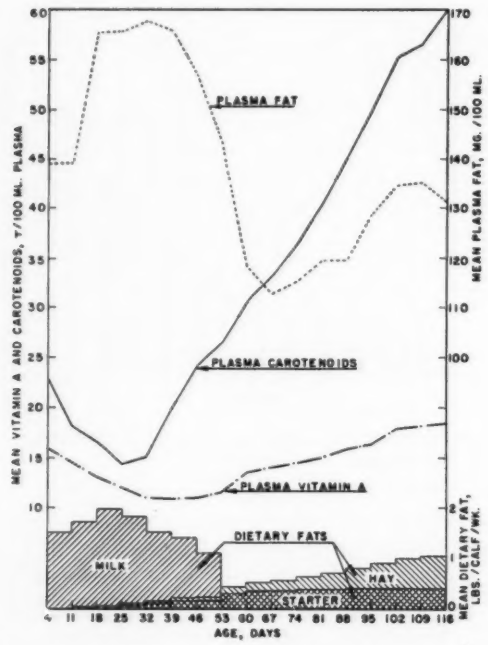

FIG. 3. Interrelationships among the fat, carotenoid, and vitamin A levels of blood plasma and the calculated dietary fat.

nomenon, although contrary to the expected, is in agreement with other findings *(16, 17, 18, 20)*.

Figure 4 indicates blood glucose levels of animals in the present experiment (normal diet) compared with those of animals on milk diets only (milks containing milk fat or hydrogenated soybean oil, *19)* and on a skimmilk diet (fasting

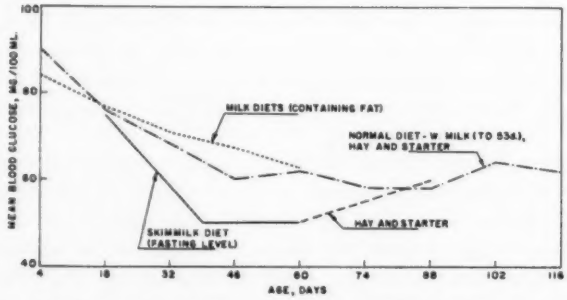
MILK DIETS (CONTAINING FAT)
NORMAL DIET - W MILK (TO 534), HAY AND STARTER
HAY AND STARTER
SKIMMILK DIET (FASTING LEVEL)
MEAN BLOOD GLUCOSE, MG./100 ML.
AGE, DAYS

FIG. 4. Effect of diet on blood glucose levels of dairy calves. (Values for normal diet represent data from present study; values for milk diets containing fat and for skimmilk diet are based on data reported by Wing *(19)* and by Murley *et al. (11)*, respectively.)

level, *11*). The lower blood glucose levels (at 39 and 60 days) for calves on the skimmilk diet might be explained in part by difference in bleeding time. In this group (skimmilk diet) blood samples were taken at feeding time, whereas blood samples for the other groups were taken approximately 3 hours after feeding. In all groups of calves blood glucose levels declined steadily until approximately 5 to 8 weeks of age. Calves on the "milk diets containing fat" and on the "skimmilk diet" received no feeds other than the milks during the period to 60 days of age. Nevertheless, the blood reducing sugar levels decreased at approximately the same rate as those of animals fed hay and concentrates (normal diet). This observation is in agreement with Reid *(12)* and Jacobson *et al. (7)* but is not in accord with the observations of McCandless and Dye *(9)*, who found the blood reducing sugar level to be inversely related to size and functional development of the rumen. The data in Figure 4 indicate that marked postnatal decreases in blood reducing sugar levels occur even though the diet is not conducive to functional development of the rumen.

SUMMARY

Six starter mixtures were compared in the rations of dairy calves during the period from 4 to 116 days of age. The respective concentrate mixtures varying from simple to relatively "complex" in composition were fed (maximum of 4 lb. daily per calf) to six comparable groups of calves. All calves were fed a limited amount of whole milk during the period from 4 to 53 days of age, and good quality alfalfa hay was fed ad libitum. There were no significant differences among groups in mean weight gains, incidence of diarrhea, blood reducing sugar values, or in blood plasma fat, vitamin A, and carotenoids. The plasma fat values (all groups combined) were closely correlated with dietary fat intake and were lowest at approximately 9 weeks. Plasma carotenoid values decreased during the initial 3 weeks and increased rapidly thereafter. Vitamin A levels were lowest during the last 3 weeks of the milk feeding period and increased sharply upon removal of the milk from the ration. Blood glucose values declined the first 6 weeks and remained relatively constant thereafter.

REFERENCES

(1) Allen, N. N. Blood Fat of Dairy Cattle. 1. A Simple Volumetric Method for Determining Blood Fat. 2. Factors Influencing the Fat Content of Blood Plasma. Minn. Agr. Expt. Sta., *Tech. Bull.* 130. 1938.

(2) Allen, R. S., Wise, G. H., and Jacobson, N. L. Occurrence in Blood Plasma from Certain Dairy Calves of Factors that Interfere with the Color Reactions of Activated Glycerol Dichlorohydrin with Vitamin A and Carotenoids. *J. Dairy Sci.*, **32**: 688. 1949.

(3) Barker, H. B., Wise, G. H., and Jacobson, N. L. Filled Milks for Dairy Calves. III. Comparative Value of Various Soybean Oils and Butter Oil in a Practical Dietary Regime. *J. Dairy Sci.*, **35**: 507. 1952.

(4) Boyer, P. D., Phillips, P. H., Lundquist, N. S., Jensen, C. W., and Rupel, I. W. Vitamin A and Carotene Requirements for the Maintenance of Adequate Blood Plasma Vitamin A in the Dairy Calf. *J. Dairy Sci.*, **25**: 433. 1942.

(5) GARDNER, K. E. Simplified Calf Starter Containing Corn, Oats, and Expeller or Solvent Soybean Oil Meal. *J. Dairy Sci.*, **35**: 491. 1952.

(6) HIBBS, J. W., POUNDEN, W. D., AND CONRAD, H. R. A High Roughage System for Raising Calves Based on the Early Development of Rumen Function. I. Effect of Variations in the Ration on Growth, Feed Consumption, and Utilization. *J. Dairy Sci.*, **36**: 717. 1953.

(7) JACOBSON, N. L., ALLEN, R. S., AND BELL, M. R. The Effect of Various Feeding Systems on Growth and Certain Blood Constituents of Dairy Calves. *J. Animal Sci.*, **10**: 1050. 1951.

(8) LAMBERT, M. R., JACOBSON, N. L., ALLEN, R. S., AND ZALETEL, J. H. Lipid Deficiency in the Calf. *J. Nutrition*, **52**: 259. 1954.

(9) MCCANDLESS, E. L., AND DYE, J. A. Physiological Changes in Intermediary Metabolism of Various Species of Ruminants Incident to Functional Development of Rumen. *Am. J. Physiol.*, **162**: 434. 1950.

(10) MOORE, L. A., AND BERRY, M. H. Vitamin A and Carotene Content of the Blood Plasma of Dairy Calves from Birth up to Four Months of Age. *J. Dairy Sci.*, **28**: 821. 1945.

(11) MURLEY, W. R., JACOBSON, N. L., AND ALLEN, R. S. The Effect of Aureomycin Supplementation on Growth and Feed Utilization of Young Dairy Calves. *J. Dairy Sci.*, **35**: 846. 1952.

(12) REID, R. L. Studies on the Carbohydrate Metabolism of Sheep. IV. Interrelationships Between Changes in the Distribution and Levels of Glucose and in the Levels of Volatile Fatty Acid in the Blood of Lambs. *Australian J. Agr. Research*, **4**: 213. 1953.

(13) SNEDECOR, G. W. *Statistical Methods.* 4th ed. Iowa State College Press, Ames. 1946.

(14) SOMOGYI, M. Determination of Blood Sugar. *J. Biol. Chem.*, **160**: 69. 1945.

(15) SOMOGYI, M. Studies of Arteriovenous Differences in Blood Sugar. I. Effect of Alimentary Hyperglycemia on the Rate of Extrahepatic Glucose Assimilation. *J. Biol. Chem.*, **174**: 189. 1948.

(16) THOMAS, J. W., JACOBSON, W. C., AND MOORE, L. A. Factors Unrelated to Vitamin A Intake that Influence Plasma Vitamin A Concentration. *J. Dairy Sci.*, **35**: 679. 1952.

(17) THOMAS, J. W., JACOBSON, W. C., AND WHITBY, E. G. Variations in Plasma Vitamin A Concentrations Affected by Dietary Regime other than Vitamin A Intake. *J. Animal Sci.*, **8**: 631. 1949.

(18) THOMAS, J. W., AND MOORE, L. A. Plasma and Storage Levels of Vitamin A and Carotene in Relation to Intake by Calves on Different Diets. *J. Dairy Sci.*, **35**: 687. 1952.

(19) WING, J. M. Effect of Milk Products Reconstituted with Different Fats on Growth and Blood Constituents of Dairy Calves. Unpublished thesis. Iowa State College, 1952.

(20) WISE, G. H., CALDWELL, M. J., PARRISH, D. B., ATKESON, F. W., AND HUGHES, J. S. Relation of Typical Postnatal Changes in the Diet of the Dairy Calf to the Concentration of Carotenoids and Vitamin A in the Blood Serum. *J. Animal Sci.*, **7**: 70. 1948.

PRODUCTION OF LACTIC ACID AND AN IODINE STAINING SUBSTANCE BY BOVINE RUMEN BACTERIA

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Some years ago, Baker *(1)* divided the microorganisms of the rumen into iodophilic and aniodophilic forms, depending on the color produced within them upon application of an iodine staining solution. Iodophilic forms stained blue-mauve and many were considered to possess cellulolytic abilities. Earlier, Henneberg *(10)* observed cocci in enzymatically dissolved zones ("frassbette") in plant fragments from rumen contents. These organisms stained wine-red upon application of an iodine staining solution.

Recently, Oxford *(16)* and Masson and Oxford *(15)* found that holotrich ciliates from the rumen of sheep were active in depositing intracellular polysaccharide granules. The polysaccharide stained brownish-purple and was considered a reserve substance, starch-like in nature. This substance was synthesized from glucose, fructose, sucrose, inulin, and bacterial levan and to a lesser extent from cellobiose, but not from maltose. Heald *(9)* observed rapid increases in stored polysaccharide after feeding, followed by an equally rapid decline. This worker did not agree with Baker's *(2)* suggestion that polysaccharide synthesis represented a mechanism whereby a source of carbohydrate was available in the intestine, since he believed that most of it was broken down before leaving the rumen. Elsden *(7)* noted the formation of an iodine staining material in rumen microorganisms when glucose was fed. In vitro observations also were made with whole rumen liquor diluted 1:10 in a buffered salt-substrate mixture incubated anaerobically. Finally, Doetsch *et al. (5)* reported that an iodine staining substance (ISS) was produced by mixed suspensions of rumen bacteria in vitro from carbohydrates but not from citric acid cycle compounds or fatty acids through C4.

In the paper above *(5)* it also was stated that lactic acid was not found in rumen liquor of normal animals on a hay and grain diet except in trace amounts. Phillipson and McAnally *(18)* reported that lactic acid appeared transiently when a cabbage-mangold diet was fed or when glucose was introduced into the rumen. In the work of Elsden *(7)* cited above it was found that the fermentation of glucose by rumen microorganisms resulted in lactic acid production, but this metabolite was subsequently transformed to lower fatty acids. Further, Elsden demonstrated that the organisms in whole rumen liquor fermented lactate to fatty acids, mainly propionic. Hungate *et al. (12)* found that considerable non-volatile acid (presumably lactic) accumulated in the rumen of sheep fed glucose or changed abruptly from a diet of hay to grain.

A two-fold effect of carbohydrates on rumen bacteria and protozoa is evident,

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namely, lactic acid production and polysaccharide synthesis. Results of further studies on the production of these substances are presented in this paper. If the conditions governing these reactions could be discovered, one might be able to make an estimate of the "normalcy" of the physiological state of the bacterial flora in the rumen of the intact animal. It is suggested that if bacteria taken as mixed suspensions from a given animal are markedly at variance in some physiological way from those of normal animals one might legitimately suspect some malfunction in these bacteria. This condition might further be reflected in some abnormal condition in the animal. It is emphasized that until now this is a speculative view and further work must be done to support or disclaim it. It should be noted that in vivo reactions were verified from in vitro experiments with washed suspensions of rumen bacteria in recent excellent work by Lewis *(13)*.

EXPERIMENTAL PROCEDURE

Collection of sample, preparation of cell suspension, and procedure for the dissimilation test have been described previously *(5)*. The rumen liquor samples were obtained from a 6-year-old Jersey cow fitted with a permanent rumen fistula. The animal's diet consisted of alfalfa hay and a 16% protein grain mixture. Two hundred micromoles of substrate were used in each flask (final volume with cell suspension, buffer, and substrate in each case was 11 ml.). After appropriate incubation time (noted below for each experiment) the fermentation mixture was assayed for lactic acid *(3)*, ISS, and in some cases, volatile fatty acids *(8, 14)*. By "ISS" is meant that substance within the bacteria which imparts a dark blue or brownish-blue coloration to 0.1 ml. of the fermentation mixture when it is treated with one drop of Lugol's iodine solution. The test was carried out on a spot plate. The effect of various factors, possibly attained in vivo under certain conditions, on the production of lactic acid and ISS was studied.

The influence of pH on the two reactions was determined by use of *M*/15 phosphate buffers at pH 5.0, 6.9, and 8.0. In processing a rumen sample, the cells were finally suspended in buffer at the pH at which they were to be studied. Glucose and maltose were used as substrates, and their complete utilization after 24 hours was noted by testing for residual carbohydrate with Benedict's reagent *(11)*.

The effect of substrate concentration and length of incubation period on the two reactions was studied. Various concentrations of maltose (20 to 2,000 μM per 11 ml.) were incubated for periods of 1 to 72 hours, and at intervals the fermentation mixture was assayed for lactic acid, ISS, and, occasionally, fatty acids. Compounds postulated to give rise to lactic acid almost directly were tested in high concentrations since they failed to yield this metabolite at the 200μM level. The sodium salts of pyruvic, malic, and succinic acids were used as substrates at a concentration of 2,000μM per 11 ml. Lactic acid was determined after 24 hours incubation.

It was observed that ISS produced from a given carbohydrate was utilized within 24 to 48 hours after a qualitative test for reducing sugar was negative. An attempt was made to accelerate this process by adding 0.5 mg. each of adenylic acid and magnesium (as $MgSO_4 \cdot 7H_2O$) in cellobiose dissimilation experiments.

Burroughs *et al. (4)* reported increased utilization of urea and cellulose in an artificial rumen through use of a mineral salt solution. A study was made to determine the effect of this solution on the utilization of starch and cellobiose. Dissimilation experiments were performed with 200μM of each of these substrates (calculated as starch) and 0.5 ml. of salt solution per 11 ml. under atmospheres of nitrogen or carbon dioxide. In the latter case 0.5 ml. of a 10% solution of $NaHCO_3$ was added to the buffer before gassing. Appropriate controls were used in all cases.

In order to determine the effect of binding metal ions on the two reactions a chelating agent was employed. In this case sodium versenate (sodium salt of ethylene-diamine tetra acetic acid, EDTA) was added to give a final concentration of 0.0014 M in glucose dissimilation experiments.

Doudoroff *et al. (6)* reported the direct utilization of maltose by *Escherichia coli* with the formation of a polysaccharide. These workers found that NaF or sodium iodoacetate inhibited this process. In the present work 0.15 M NaF was employed in cellobiose or maltose dissimilation experiments. The precise amount of reducing sugar present was determined initially and terminally by the Shaffer-Hartman-Somogyi method *(19, 20, 21)*. Tests were conducted under nitrogen or carbon dioxide atmospheres and in the latter case with 0.1 M $NaHCO_3$ (pH 7.1) as buffer.

TABLE 1

Conditions which affect the production of an iodine staining substance (ISS) by bovine rumen bacteria

Substrate	Condition	ISS present after 24 hours
Glucose	pH 5.0, 8.0	weak +
Glucose	pH 6.9	+
Maltose	20μM instad of 200 μM	−
Maltose	0.15 M NaF added	−
Cellobiose	0.15 M NaF added	−
Glucose	0.0014 M EDTA added	weak +
Cellobiose	Salt solution added	weak +
Starch	Salt solution added	−
Cellobiose	Adenylic acid + Mg added	+

RESULTS AND DISCUSSION

In Table 1 are summarized the results of experiments on the conditions under which ISS was formed. It can be seen that it was produced at all pH levels used, although at pH 5.0 and 8.0 only in relatively small amounts as compared to that formed at pH 6.9. The substrates were not completely utilized in 24 hours at pH 5.0. A pH of 5.0 or 8.0 represents reactions not normally found in the rumen, and it seems reasonable to assume that a difference in amount of ISS formed might be encountered at sub-optimal pH levels.

ISS produced from 200μM of substrate is considered a consequence of the presence of a readily available energy source in excess of the immediate capacity of the rumen bacterial suspensions to either ferment or polymerize to another form, viz., capsular substances. When smaller concentrations of carbohydrate (20μM per 11 ml.) were incubated for 24 hours, no ISS was detected. However, failure to find this substance was due to the fact that it was completely utilized within this period. When the fermentation mixture was assayed after 1 hour, ISS was found. This means that ISS was formed at a concentration of 1.8μM of carbohydrate per milliliter and in the presence of a concentration of bacteria much greater per unit volume than found in normal whole rumen liquor. The level of soluble carbohydrate is never very high in the rumen, but from this experiment it is suggested that a concentration of 2μM of soluble carbohydrate per milliliter of rumen liquor in vivo would be sufficient to give the ISS reaction. ISS was not found after 72 hours incubation of 200μM of substrate, and this implicates it as a reserve substance. The observations of Oxford *(16)* and Heald *(9)* on protozoa and of Elsden *(7)* on bacteria in this regard are similar to these findings.

Adenylic acid and magnesium ions did not affect the rate of utilization of ISS. It was concluded that these adjuncts must have been present in sufficient amounts in the suspensions or else they were not operative as such in the system.

The utilization of ISS by rumen bacteria in vivo probably occurs much faster because of less available carbohydrate, removal of inhibitory products, etc. Preliminary experiments have shown that acetic, propionic, and butyric acids do not alter the rate at which ISS is formed.

In the presence of the salt solution, little, if any, ISS was found after 24 hours incubation of 200μM of starch or cellobiose. There was also an increased amount of volatile fatty acids in the fermentation liquor from these experiments. It seems that the inclusion of salts had some accelerating effect on the utilization of ISS. Results were the same with carbon dioxide and nitrogen.

EDTA prevented the utilization of 200μM of glucose, and only a small amount of ISS was formed. The importance of metallic ions in ISS formation is thus inferred, although the toxicity of EDTA per se has not been completely ruled out. The necessary metallic ions are no doubt present in rumen fluid in excess of their actual need and in any event are not removed absolutely by the method of cell preparation.

Sodium fluoride prevented the formation of ISS and resulted in a 100% increase in reducing sugar when 200μM of maltose were used. This indicated that the disaccharide fermentation was inhibited after the formation of monosaccharide units. The reaction is thus similar to that described by Doudoroff *et al. (6)*. Greater consistency of results was noted with a carbon dioxide-bicarbonate system than with a nitrogen-phosphate system.

The effect of pH on the production of lactic acid was interesting. No lactic acid was produced at pH 6.9 from 200μM of glucose, maltose, or cellobiose after 24 hours incubation. On the other hand, lactic acid was produced consistently

at pH 5.0 and 8.0. This indicated that at pH levels sufficiently different from that normal to the rumen, enzyme systems which dissimilate lactic acid are inoperable and thus it accumulates, or at these levels greater amounts of lactic are formed than can be dissimilated. When substrate concentrations in excess of 200μM per 11 ml. were tested, viz., 2,000μM, rather large amounts of lactic acid accumulated in the fermentation liquor after 24 hours incubation, even at pH 6.9.

The production of lactic acid in experiments involving the use of excess carbohydrate reveals possible applications of this in vitro technique. For example, Phillipson *(17)* observed that lactic acid was formed in the rumen when flaked maize was included in the diet, and earlier Phillipson and McAnally *(18)* obtained similar results by feeding glucose. The work of Hungate *et al. (12)* pointed out similar changes in the nonvolatile acid content of the rumen upon feeding grain or glucose. The results presented here reveal the same thing in a simple, direct manner. It seems that a wide variety of in vitro experimental conditions could be devised and the results used to predict probable in vivo reactions. Expensive, time-consuming in vivo experiments might thereby be eliminated. It is, of course, necessary to verify these reactions in the intact animal, and the technique advocated here is to be construed as a guide and not a final resort.

The production of lactic acid is usually associated with lactic acid bacteria. A good lead is furnished as to the probable physiological type of bacteria to be expected when excess carbohydrate is fed. In the work of Hungate *et al. (12)* the cultural investigations on the rumen contents revealed the predominance of a lactic acid bacterium. It is our belief that the technique employed by us may be useful not only in predicting probable changes that would occur in the rumen when a particular compound was fed, but that it would furnish information as to the type of bacteria to seek in cultural investigations.

Lactic acid was not produced from xylose or arabinose regardless of concentration employed. This was considered significant, since if true lactic acid bacteria are responsible for the lactic acid production observed one would not expect them to ferment these pentoses.

The speed of centrifuging the final material used in preparing the cell suspension governed to some extent the appearance of lactic acid in the fermentation liquor. No other metabolic difference between cell suspensions prepared at different speeds has been noted. In the work reported on above, the final centrifugation was at 1,952 × G. and obviously these preparations yielded little, if any, lactic acid from 200μM substrate at pH 6.9 after 24 hours incubation. If the final centrifugation was done at 5,782 × G. both maltose and cellobiose were found to yield lactic acid at pH 6.9 after 24 hours incubation. Curiously, lactic acid was not found in glucose dissimilation tests under these conditions. If the fermentation liquor of a glucose dissimilation test was assayed after 2 hours incubation at pH 6.9 some lactic acid was found, and this was interpreted to mean that much more lactic acid results from the dissimilation of the di-

saccharides than from glucose. Approximately 375 to 400μM of lactic acid accumulated from 200μM of maltose or cellobiose after 24 hours incubation at pH 6.9 when the new method of cell preparation was employed. Since the new method is now used routinely it will be described as follows: The whole rumen liquor is strained through four layers of cheesecloth and centrifuged for 2 minutes at 771 × G. This is repeated with the supernatant for 10 minutes. Finally, the supernatant is centrifuged for 10 minutes at 5,782 × G. and suspended in buffer and standardized as previously described *(5)*. The supernatant after the last centrifuging is perfectly clear.

Pyruvate, succinate, and malate yielded no lactic acid when supplied at the 200μM level and from 30 to 60μM of lactic acid from pyruvate and malate when supplied at the 2,000μM level. It is unlikely that such high concentrations of these substrates are ever found in the rumen since they are rapidly utilized by rumen bacteria. A possible explanation may be that organisms which rapidly attack these C3 and C4 compounds, viz., *Veillonella* sp., compete with the lactic acid bacteria for them. Lactic acid is not produced by *Veillonella* sp. from pyruvate, malate, or succinate; further, they cannot ferment hexose carbohydrates and they would not compete with lactic acid bacteria in this case; hence one might explain the production of lactic acid from hexoses but not C3 and C4 compounds.

SUMMARY

The effect of some conditions on the in vitro formation of an iodine staining substance (ISS) and lactic acid by rumen bacteria has been investigated. Most of the conditions studied could conceivably occur in the rumen at some time; included were alteration of pH, change of substrate concentration, addition of salt mixtures, and inhibitors.

The production of ISS by rumen bacteria is probably a mechanism which enables them to store a reserve energy supply. It is doubtful whether this reaction is confined solely to rumen microorganisms.

Lactic acid was produced from glucose, fructose, maltose, and cellobiose but not from xylose or arabinose. Accumulation of lactic acid occurred when carbohydrate in excess of 200μM per 11 ml. or cell preparations from high speed centrifugation were used. Lactic acid was detected from glucose (200μM) after 2 hours incubation but not after 24 hours regardless of the method of cell preparation.

Pyruvate, malate, and succinate yielded scant amounts of lactic acid even when 2,000μM were used.

Some suggestions are given for use of the washed suspension technique for the solution of practical problems and, more important, for uncovering basic information on the physiological reactions of rumen bacteria when examined as an enzymatically competing population.

REFERENCES

(1) Baker, F. Normal Rumen Microflora and Microfauna. *Nature*, **149**: 220. 1942.

(2) Baker, F. Microbial Factors in the Digestive Assimilation of Starch and Cellulose in Herbivora. *Nature*, **150**: 479. 1942.

(3) Barker, S. B., and Summerson, W. H. The Colorimetric Determination of Lactic Acid in Biological Material. *J. Biol. Chem.*, **138**: 535. 1941.

(4) Burroughs, W., Latona, A., DePaul, P., Gerlaugh, P., and Bethke, R. M. Mineral Influences upon Urea Utilization and Cellulose Digestion by Rumen Microorganisms Using the Artificial Rumen Technique. *J. Animal Sci.*, **10**: 693. 1951.

(5) Doetsch, R. N., Robinson, R. Q., Brown, R. E., and Shaw, J. C. Catabolic Reactions of Mixed Suspensions of Bovine Rumen Bacteria. *J. Dairy Sci.*, **34**: 825. 1953.

(6) Doudoroff, M., Hassid, W. Z., Putnam, E. W., Potter, A. L., and Lederberg, J. Direct Utilization of Maltose by *Escherichia coli*. *J. Biol. Chem.*, **179**: 921. 1946.

(7) Elsden, S. R. The Fermentation of Carbohydrates in the Rumen of the Sheep. *J. Exptl. Biol.*, **22**: 51. 1945.

(8) Elsden, S. R. The Application of the Silica Gel Partition Chromatogram to the Estimation of Volatile Fatty Acids. *Biochem. J.*, **40**: 252. 1946.

(9) Heald, P. J. The Assessment of Glucose Containing Substances in Rumen Microorganisms During a Digestion Cycle in Sheep. *Brit. J. Nutrition*, **5**: 84. 1951.

(10) Henneberg, W. Untersuchungen über die Darmflora des Menschen mit Besonderer Berücksichtigung der Jodphilen Bakterien im Menschen und Tierdarm sowie im Kompostdunger. *Centr. Bakteriol. Parasitenk.*, Abt. II, **55**: 242. 1922.

(11) Hepler, O. E. *Manual of Clinical Laboratory Methods*. 4th ed. Charles C. Thomas, Springfield, Ill. 1951.

(12) Hungate, R. E., Dougherty, R. W., Bryant, M. P., and Cello, R. M. Microbiological and Physiological Changes Associated with Acute Indigestion in Sheep. *Cornell Vet.*, **42**: 423. 1952.

(13) Lewis, D. The Reduction of Sulfate in the Rumen of the Sheep. *Biochem. J.*, **56**: 391. 1954.

(14) Liddell, H. F., and Rydon, H. N. A New Indicator for Use in Partition Chromatography: 3,6,-β-naphthalene-azo-N-phenyl-α-naphthylamine. *Biochem. J.*, **38**: 68. 1944.

(15) Masson, F. M., and Oxford, A. E. The Action of the Ciliates of the Sheep's Rumen upon Various Water Soluble Carbohydrates, Including Polysaccharides. *J. Gen. Microbiol.*, **5**: 664. 1951.

(16) Oxford, A. E. The Conversion of Certain Soluble Sugars to a Glucosan by Holotrich Ciliates in the Rumen of Sheep. *J. Gen. Microbiol.*, **5**: 83. 1951.

(17) Phillipson, A. T. The Fatty Acids Present in the Rumen of Lambs Fed on a Flaked Maize Ration. *Brit. J. Nutrition*, **6**: 190. 1952.

(18) Phillipson, A. T., and McAnally, R. A. Studies on the Fate of Carbohydrate in the Rumen of Sheep. *J. Exptl. Biol.*, **19**: 199. 1942.

(19) Shaffer, P. A., and Somogyi, M. Copper-Iodometric Reagents for Sugar Determinations. *J. Biol. Chem.*, **100**: 695. 1933.

(20) Somogyi, M. A New Reagent for the Determination of Sugars. *J. Biol. Chem.*, **160**: 61. 1945.

(21) Somogyi, M. Determination of Blood Sugar. *J. Biol. Chem.*, **160**: 69. 1945.

THE ADEQUACY OF SOME PASTURES AS THE SOLE SOURCE OF NUTRIENTS FOR GROWING CATTLE

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Very little data are available on the amount and digestibility of the protein and the amount of total digestible nutrients (TDN) in herbage selected by grazing animals. Most of the information on this subject has been obtained by analyzing chemically, and feeding in digestion trials, herbage sampled manually. As a consequence, existing data do not necessarily apply to the herbage consumed by grazing animals. Studies of plucked or clipped herbage do not provide definite indications of the kinds of pastures which require supplementation.

As demonstrated in a recent study *(3)*, the herbage consumed by grazing cattle contains more crude protein and more highly digestible protein than herbage clipped from the same source at a stubble height of approximately 2 in. Although the results of that experiment suggest that less supplemental protein is needed by grazing animals than by animals fed whole herbage harvested from the same source, information on the total intake of protein and other nutrients is needed in order to draw definite conclusions.

The data summarized in the present report were obtained in experiments originally intended to work out methods of measuring the composition, digestibility, and intake of grazed herbage *(2, 3, 7)*. Although these experiments were not designed specifically to study the nutritional adequacy of pastures, they do provide valuable information on the intake of nutrients by growing cattle. It is the purpose of the present study to extend the results of a previous experiment *(3)* and to examine the adequacy of the digestible protein and TDN intakes from a variety of pastures for growing cattle.

EXPERIMENTAL PROCEDURE

The herbages of each of six pastures were simultaneously hand-fed to, and grazed by, similar groups of steers throughout the grazing season or period of investigation. Both groups of steers (hand-fed and grazing) had access to the same herbage. The hand-feeding trials have no significance in the present study other than that of providing certain data needed to measure the composition and digestibility of the grazed herbage *(3)*. During periods of 4 to 11 days occurring at 16- to 35-day intervals, the composition, digestibility, and amount of each herbage consumed were measured. In this way, each pasture was studied at three to five stages of plant growth.

The groups used in 21 of the trials were composed of three animals. In the remaining three trials, the grazing groups were composed of two steers. All steers were Holsteins except one grazing Pasture 1 and two grazing Pasture 6,

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which were of beef breeding. The range in beginning weights of the steers grazing the pastures were: Pasture 1, 336 to 438 lb.; Pastures 2, 3, and 4, 350 to 570 lb.; Pasture 5, 320 to 700 lb., and Pasture 6, 320 to 950 lb. Pasture herbage constituted the entire rations of the animals.

Body weight measurements were made at the same time of day on six or seven consecutive days before and/or during the digestion trials and on three consecutive days mid-way between trials. In Table 2 are recorded the weight gains found during periods of 16- to 28-days duration. The dates shown in Table 2 are the mean dates of the periods during which body weights of the steers and the intake, composition, and digestibility of the herbages were measured.

The methods employed to measure digestibility *(7)* and composition *(3)* were described previously. The dry matter intake was derived from the total fecal outgo measured with collection bags, and indigestibility coefficients determined by the fecal-chromogen procedure *(2)*. These measurements were employed in the computation of the digestible protein and TDN intakes of the individual animals. A more detailed description of these experiments is presented in an earlier paper *(3)*.

The extent to which the various pastures satisfied the digestible protein and total nutrient needs of growing cattle was determined by comparing the minimum levels of digestible protein and TDN recommended by Morrison *(6)* to those consumed by animals of the same size. The minimum requirements of digestible protein for growth of Holstein heifers reported by Lofgreen *et al. (4)* are remarkably similar to the minimum allowances for growing dairy cattle recorded in the Morrison Standards. Morrison's data were found to be expressed accurately by the equation, $Y = 0.8704 \log X - 0.00025 X - 1.42$, where: Y = digestible protein (lb/day) and X = body weight (lb.). The equation, $Y = 4.6324 \log X + 0.00459 X - 7.95$, where: Y = TDN (lb/day) and X = body weight (lb.), gave an excellent fit to Morrison's allowances of TDN. These equations were employed to compute the needs of the individual animals used in this investigation.

RESULTS

Data pertinent to this investigation are summarized in Tables 1 and 2. Botanical composition and growth stages of the plants in the pasture mixtures employed are recorded in Table 1. The dates listed (Table 2) are mean dates of the periods (4 to 11 days) during which the composition, digestibility, and intake of the various pastures were studied. With the exception of the aftermaths, all pastures studied were first-growth herbages which had been allowed to grow uninterruptedly until grazed.

Pasture 1 consisted largely of timothy and Kentucky bluegrass. Through approximately June 10, this pasture provided sufficient protein and TDN to satisfy the minimum allowances for growing cattle recorded in the Morrison Feeding Standards *(9)*. Between June 10 and June 26, the protein and TDN contents of the herbage decreased to such an extent that the animals consumed

TABLE 1

Botanical composition of pasture mixtures and growth stages of individual plants

Pasture mixture	Trial No.									
	1		2		3		4		5	
Pasture 1										
Timothy	V[a]	(58.0)[b]	EH	(70.0)	FBl	(78.0)				
Ky. bluegrass		(27.0)		(25.0)		(18.0)				
Quack grass		(6.0)		(2.0)						
Weeds		(9.0)		(3.0)		(4.0)				
Pasture 2										
Ky. bluegrass	EH[1]	(43.5)[2]	EBl	(44.8)	S	(40.0)	S	(34.4)		
Timothy	V	(26.6)	EH	(31.5)	EBl	(40.0)	FBl	(30.8)		
Meadow fescue	V	(12.7)	H	(9.4)	FH	(14.8)	S	(18.6)		
Quack grass	V	(9.1)	V	(5.0)						
Weeds		(8.0)		(9.4)		(5.2)		(1.6)		
Red top							FBl	(14.6)		
Pasture 3										
Timothy	V	(38.9)	EH	(19.4)	EBl	(8.4)	V-EH	(44.5)	EH	(8.5)
Quack grass	V	(31.1)	H	(57.9)	S	(86.0)	V	(21.4)	V	(30.7)
Alfalfa	V	(18.2)	V	(17.3)	V	(5.1)	V	(19.4)	V-EBl	(57.8)
Clover	V	(11.5)	V	(2.8)	V	(0.6)	V-EH	(11.3)		
Weeds		(0.3)		(2.6)				(3.5)		
Dead material										(2.9)
Pasture 4										
Quack grass	V	(66.2)	H	(84.3)	S	(52.1)	V	(19.5)	V	(24.7)
Timothy	V	(20.7)	EH	(9.4)	EBl	(39.9)	V-EH	(4.8)	EH	(2.8)
Alfalfa	V	(9.9)			V	(7.3)	V	(64.0)	V-EBl	(60.1)
Clover	V	(3.1)	V	(3.5)			V	(5.8)	V	(4.4)
Ky. bluegrass			EBl	(2.8)	S	(0.7)				
Weeds		(0.1)								(0.9)
Dead material								(5.9)		(7.1)
Pasture 5										
Brome grass	FH	(98.0)	S	(89.5)	V	(65.8)				
Red clover	Bl	(0.6)								
Red top			FBl	(7.3)						
Weeds		(1.4)		(3.2)		(12.9)				
Dry dead material						(21.3)				
Pasture 6										
Alfalfa	Bl	(80.7)	PBl	(79.8)	EBl	(80.0)				
Brome grass	H	(10.1)	S	(10.5)	V	(10.0)				
Weeds		(9.2)		(9.7)		(10.0)				

[a] The following abbreviations are employed for the growth stage: V = vegetative, EH = early head, H = head, FH = full head, EBl = early bloom, FBl = full bloom, PBl = post bloom, and S = seed.

[b] Figures in parentheses represent percentages of various plants in the mixture harvested at a stubble height of 2 in. All percentages except those for Pasture 1 are expressed on dry weight basis; data for Pasture 1 are based on green weight.

about 0.2 lb. per day less of digestible protein and 0.9 to 1.3 lb. per day less of TDN than they needed.

Pasture 2 was similar botanically to Pasture 1. The amount of digestible protein consumed in this mixture during late June and early July was about 0.2 lb. less per day than that which was needed. This deficit increased to 0.5 to 0.6 lb. of digestible protein per day by July 18. Although the average daily gains

TABLE 2

Body weight gains, nutrient intakes, and mean dates of trials

Trial No.	Mean date of trial	Steer No.	Body wt. gain	Digestible protein		TDN	
				Needed[a]	Consumed	Needed[a]	Consumed
			(lb/day)	*(lb/day)*		*(lb/day)*	
			Pasture 1				
1	May 24	0	2.4	0.74	1.36	5.8	6.9
	(1st growth)	36	2.7	0.74	1.89	5.9	10.6
		39	2.6	0.70	1.54	5.4	8.9
2	June 10	0	1.4	0.76	0.95	6.2	6.7
	(1st growth)	36	2.1	0.77	1.17	6.2	8.2
		39	1.6	0.72	0.81	5.6	6.3
3	June 26	0	0.6	0.77	0.54	6.3	4.0
	(1st growth)	39	1.2	0.74	0.56	5.9	5.0
			Pasture 2				
1	May 28	4	3.9	0.78	2.05	6.4	8.3
	(1st growth)	5	2.4	0.75	1.61	6.0	6.0
		6	2.6	0.74	1.73	5.8	6.6
2	June 14	4	1.5	0.80	0.99	6.7	6.2
	(1st growth)	5	1.5	0.77	0.79	6.3	5.0
		6	2.2	0.76	0.83	6.1	5.2
3	July 1	4	1.6	0.82	0.71	7.1	6.4
	(1st growth)	5	1.5	0.79	0.66	6.6	4.9
		6	1.0	0.78	0.61	6.5	5.0
4	July 18	4	0.1	0.83	0.28	7.3	6.2
	(1st growth)	5	−0.2	0.80	0.25	6.8	4.7
		6	0.6	0.80	0.25	6.7	5.4
5	Aug. 4	4	2.2	0.83	—[b]	7.3	9.5[c]
	(aftermath)	5	2.4	0.81	—	6.9	6.8
		6	2.2	0.81	—	6.9	9.4
			Pasture 3				
1	June 2	10	2.9	0.78	2.46	6.5	8.5
	(1st growth)	11	2.7	0.75	1.60	6.0	6.2
		12	2.4	0.74	1.48	5.8	5.5
2	June 19	10	2.4	0.81	2.06	7.0	8.1
	(1st growth)	11	2.1	0.78	1.50	6.4	6.0
		12	1.1	0.76	1.57	6.2	5.7
3	July 6	10	1.4	0.82	0.99	7.1	8.2
	(1st growth)	11	1.6	0.80	0.84	6.7	6.5
		12	1.1	0.78	0.62	6.4	4.5
4	July 23	10	1.4	0.83	1.85	7.4	7.9
	(aftermath)	11	0.8	0.80	1.48	6.8	6.7
		12	0.2	0.78	0.99	6.5	4.5
5	Aug. 9	10	2.3	0.85	3.07	7.6	10.4
	(aftermath)	11	1.1	0.81	2.60	6.9	9.1
		12	2.1	0.80	2.64	6.8	8.9

TABLE 2
(concluded)

Trial No.	Mean date of trial	Steer No.	Body wt. gain	Digestible protein		TDN	
				Needed[a]	Consumed	Needed[a]	Consumed
			(lb/day)	*(lb/day)*		*(lb/day)*	
			Pasture 4				
1	June 2	16	2.5	0.77	2.10	6.3	7.9
	(1st growth)	17	1.7	0.77	2.06	6.3	8.2
		18	1.5	0.71	1.36	5.5	5.3
2	June 19	16	2.5	0.79	1.58	6.6	8.6
	(1st growth)	17	2.6	0.79	1.17	6.6	6.6
		18	2.5	0.74	0.95	5.8	5.2
3	July 6	16	1.3	0.81	1.18	6.9	7.0
	(1st growth)	17	1.2	0.81	1.23	7.0	7.3
		18	1.1	0.76	0.91	6.2	5.1
4	July 23	16	1.5	0.82	2.67	7.1	8.0
	(aftermath)	17	1.8	0.82	3.40	7.1	10.0
		18	1.3	0.77	2.37	6.3	6.7
5	Aug. 9	16	1.6	0.83	2.65	7.3	9.2
	(aftermath)	17	1.5	0.84	2.89	7.4	10.3
		18	1.9	0.78	1.95	6.5	6.6
			Pasture 5				
1	June 16	23	2.6	0.74	0.75	5.8	7.4
	(1st growth)	24	2.5	0.73	0.46	5.7	4.5
		25	2.4	0.76	0.80	6.2	7.6
2	July 7	23	1.8	0.78	0.27	6.4	3.9
	(1st growth)	24	0.7	0.76	0.31	6.1	4.1
		25	1.5	0.75	0.37	6.0	4.9
3	Aug. 4	23	0.9	0.79	1.50	6.7	6.8
	(aftermath)	24	1.6	0.78	1.04	6.4	5.2
		25	0.9	0.79	1.33	6.5	6.8
			Pasture 6				
1	June 22	29	1.2	0.80	1.71	6.9	5.4
	(1st growth)	30	1.9	0.88	1.97	8.5	6.8
2	July 14	29	1.1	0.81	2.09	7.0	5.4
	(1st growth)	30	1.6	0.89	2.74	8.7	7.7
3	Aug. 18	29	0.9	0.83	2.57	7.3	7.3
	(aftermath)	30	−0.5	0.90	1.87	9.1	6.1
		31	0.9	0.93	3.22	10.2	10.4

[a] Based upon minimum allowances recorded in Morrison Feeding Standards.
[b] Digestible protein intakes were not determined as the required corollary hand-feeding trial was not conducted.
[c] Values recorded for Trial 5, Pasture 2, are pounds of digestible dry matter.

in body weight were 2.5 lb. or more in May, 1.5 to 2.0 lb. in mid-June, 1.0 to 1.5 lb. in early July, and −0.2 to 0.6 lb. in mid-July and appeared to be correlated with the digestible protein intakes, the reduction in the rate of gain accompanying increasing maturity of the herbage probably was influenced to some extent by the energy value of the herbage. As compared to the minimum allowances of TDN recommended by Morrison, the steers consumed a ration lacking 0.5 to 1.3

lb. of TDN during mid-June. This deficit ranged from 1.1 to 2.1 lb. of TDN by July 18. A sufficient amount of aftermath herbage from this pasture was consumed during early August to satisfy the needs of these animals. Average body weight gains were 2.2 to 2.4 lb. per day during the period of aftermath grazing.

Pasture 3 was studied at three stages of uninterrupted first growth and at two aftermath stages. This pasture contained 20% or more of legumes during all periods in which it was studied except that centering on July 6, when only 6% of the mixture was legumes. The steers consumed an adequate amount of protein during the first two periods (June) in which first-growth herbage was grazed and during the periods in which aftermath was grazed. During the third period of grazing first-growth herbage (July 6), two of the animals were able to satisfy their needs for digestible protein, whereas the third steer (No. 12) consumed a ration deficient in this nutrient. In general, the TDN intakes from this pasture were adequate for two of the steers. Although during the periods in which first-growth material was grazed the TDN intakes of steer 12 were 0.3 to 2.0 lb. per day lower than that generally recommended, he gained more than 1.0 lb. per day during all periods except one (July 23), in which he gained 0.2 lb. per day.

The first growth of Pasture 4 studied during three periods between early June and July 6 contained from 4 to 13% of legumes. The aftermaths of this pasture were composed of 64 to 70% of legumes. During all periods, all animals consumed an amount of digestible protein which was in excess of the minimum allowances set forth by Morrison *(6)*. The daily weight gains of the steers grazing this pasture ranged from 2.6 to 1.1 lb. The lowest rate of gain (1.1 lb/day) was obtained on the first-growth herbage grazed during the third period (July 6). Presumably the weight gains of the animals grazing Pasture 4 reflect energy, rather than protein intakes. With the exception of steer 18 whose rations lacked 0.2 to 1.1 lb. of TDN, all animals consumed an amount of TDN equivalent to, or greater than, that of the Morrison allowances.

Pasture 5, studied at two consecutive stages of first growth and one aftermath stage, consisted largely of brome grass. In mid-June, two of the steers consumed enough digestible protein and TDN to meet their need for growth, but the third animal (No. 24) did not consume enough grass to satisfy the minimum allowances for an animal of his size. By early July, all animals were consuming a ration deficient in protein and TDN. This deficit was equivalent to 0.3 to 0.5 lb. of digestible protein and 1.1 to 2.5 lb. of TDN per day. The brome grass aftermath grazed in early August provided an adequate amount of digestible protein for the growing steers used. One steer failed to consume enough TDN from the aftermath.

Pasture 6 grazed at two first-growth stages and at one aftermath stage contained 80% or more of alfalfa. This pasture provided from two to three times as much digestible protein as was needed under any of the conditions examined in this study. However, the TDN intakes were either deficient or about equivalent to the recommended allowances.

DISCUSSION

With respect to the first-growth herbages, the conditions under which these investigations were conducted are different from those generally encountered under practical conditions. In practice, pastures usually are grazed either intermittently following regrowth of the sward, or continuously. As a consequence, the amount and digestibility of protein in grazed herbage are higher at a given time during the grazing season than those of the protein in first-growth herbage as grazed during these studies. However, the stringency of these experimental conditions makes it possible to predict safely some general conditions of pasturing in which protein supplementation is required for growing cattle.

In this region, nonlegumes allowed to grow uninterruptedly until as late as mid-June before grazing provide enough protein for growing cattle. By the first of July, the intake is not great enough to satisfy the minimum allowances of digestible protein. Under the conditions of these experiments, nonlegume pastures high in timothy and Kentucky bluegrass provided enough digestible protein during a greater part of the season than did pastures high in brome grass. It is recognized that conditions such as nitrogen fertilization, temperature, and rainfall might influence the rate of plant growth and affect the adequacy of these species.

As might be expected, based upon studies of harvested legume forages, first-growth pastures containing large amounts of legumes provided more protein than is needed for growing cattle at all stages of plant growth studied.

The aftermath herbages of pastures high in nonlegumes, as well as those high in legumes, were consumed in sufficient quantity to satisfy the minimum allowances of protein even as late as August. Since, in usual grazing procedures, regrowth of herbage occurs after grazing or clipping, the results obtained with aftermath herbage in this study would appear to apply to practice more accurately than those obtained with first-growth herbages. Assuming that sufficient herbage is available for freely-grazing, growing cattle to satisfy their appetite for dry matter, it seems unlikely that a deficiency of protein will exist at any time even when the sward consists entirely of nonlegume species. Under unusual conditions, such as those imposed in these studies involving mature, first-growth herbages, the feeding of protein supplements is indicated.

Based upon comparisons with the minimum allowances of the Morrison Feeding Standards, an insufficient intake of TDN occurred more frequently and earlier in the season than that of digestible protein when the steers were grazing first-growth herbage. With few exceptions, aftermath herbage provided an adequate amount of TDN.

If it is assumed that the so-called "normal" growth standards for dairy cattle represent rates of growth which are most compatible with high levels of production during a long life span, the average daily gains from birth to 2 years of age should be approximately 1.4 and 1.1 lb. for the large and small breeds, respectively. In this investigation with Holsteins and a few beef cattle, the average daily gains during certain periods ranged from considerably more, to

somewhat less, than 1.4 lb. Since these responses were measured during relatively short periods (16 to 28 days), they may be subject to such influences as ruminal fill, prior history, and carry-over effects. Consequently, it is felt that a more accurate over-all analysis of the value of the pastures may be obtained in a consideration of the weight gains for the entire period that each pasture was grazed. The average gains of the steers grazing the pastures and the length of the grazing periods were: Pasture 1, 1.7 lb., 51 days; Pasture 2, 1.6 lb., 77 days; Pasture 3, 1.7 lb., 77 days; Pasture 4, 1.7 lb., 77 days; Pasture 5, 1.4 lb., 61 days; and Pasture 6, 1.1 lb., 73 days. In most cases, body weight increased at rates equivalent to those generally considered to be normal. Consequently, it would appear that the deficits in nutrient intakes of individual steers observed at intervals during the grazing season were not severe and may have occurred mainly during the digestibility-intake measurement trials (when the steers were carrying fecal-collection bags). In subsequent experiments *(1)* it was found that fecal-collection apparatus disturbs the behavior of animals sufficiently to reduce their consumption of grass. Other possible explanations for a good rate of growth occurring despite occasionally deficient or borderline intakes are that the TDN standard includes a safety allowance, TDN may not be a consistently accurate index of the energy value of pasture herbage, and some animals may derive more energy per unit of TDN consumed than others. Reduced intakes during prolonged periods were reflected by low rates of body weight gain.

In the conduct of the trials with Pastures 1-4 an attempt was made to graze the allotted areas to a short stubble length. Although this was not accomplished, an attempt to do so may have reduced the intake somewhat during these periods.

Since a number of physical, chemical, and nutritional characteristics of herbage are closely interrelated, the influence of individual characteristics is difficult to determine. As herbage matures, both the protein content and energy value decrease. In addition, the availability of the nutrients also decreases. As a consequence, the effects of these dietary qualities upon the response of animals may be confounded. Nevertheless, the results of this experiment with first-growth herbages suggest that a deficiency of TDN occurs earlier in the grazing season and is more critical for growing cattle than a deficiency of protein.

It has been found that, when an abundance of herbage is available, the dry matter intake is significantly correlated with the size of growing cattle and that, for a 100-lb. increment in weight, the daily dry matter intake increases by approximately 3.5 lb., irrespective of botanical composition or growth stage of the herbage *(5)*. This finding and the observations made of aftermath grazing in these investigations indicate that, under the usual conditions of grazing, growing cattle will consume an adequate amount of TDN and protein, provided that sufficient herbage is available to satisfy the appetite for dry matter.

SUMMARY

The intake, composition, and digestibility of the herbage grazed from each of six pastures by growing steers were measured at three or more stages of plant growth. The amounts of TDN and digestible protein consumed were compared

with the minimum levels recommended by Morrison for growing cattle of the same size.

With first-growth herbage (not previously grazed or harvested) a deficient intake of TDN occurred earlier in the season and more frequently than that of digestible protein. When the herbage contained an appreciable amount of legumes, the protein intake was adequate even during late stages of plant growth. Deficits in the intake of TDN and digestible protein became more marked as the herbage matured.

The results obtained in the studies of aftermath herbage are more applicable to practice than those of the experiments involving first-growth herbage. The digestible protein and, with few exceptions, the TDN intakes of steers grazing aftermaths were equivalent to, or greater than, the minimum allowances set forth by Morrison. If a sufficient amount of herbage is available to satisfy the appetite for dry matter, it appears that, in the usual grazing practice, an adequate amount of digestible protein and TDN will be consumed by growing cattle.

Severely restricted intakes of protein and/or TDN were reflected by low rates of body weight gain.

REFERENCES

(1) Brannon, W. F., Reid, J. T., and Miller, J. I. The Influence of Certain Factors upon the Digestibility and Intake of Pasture Herbage by Beef Cattle. *J. Animal Sci.*, **13**: 535. 1954.

(2) Hardison, W. A., and Reid, J. T. Use of Indicators in the Measurement of the Dry Matter Intake of Grazing Animals. *J. Nutrition*, **51**: 35. 1953.

(3) Hardison, W. A., Reid, J. T., Martin, C. M., and Woolfolk, P. G. Degree of Herbage Selection by Grazing Cattle. *J. Dairy Sci.*, **37**: 89. 1954.

(4) Lofgreen, G. P., Loosli, J. K., and Maynard, L. A. Comparative Study of Conventional Protein Allowances and Theoretical Requirements of Growing Holstein Heifers. *J. Animal Sci.*, **10**: 171. 1951.

(5) Martin, C. M., Brannon, W. F., Hardison, W. A., and Reid, J. T. Unpublished data. 1952.

(6) Morrison, F. B. *Feeds and Feeding.* 21st ed. The Morrison Publ. Co., Ithaca, N. Y. 1951.

(7) Reid, J. T., Woolfolk, P. G., Hardison, W. A., Martin, C. M., Brundage, A. L., and Kaufman, R. W. A Procedure for Measuring the Digestibility of Pasture Forage under Grazing Conditions. *J. Nutrition*, **46**: 255. 1952.

A STUDY OF THE SEASONAL SLIT-OPENNESS DEFECT IN CHEDDAR CHEESE[1]

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The slit-openness defect in Cheddar cheese, which occurs more often in the fall and winter months, has become increasingly important to the cheese industry. The defect is never evident when the cheese leaves the press but develops during the early stages of ripening. This open-texture defect can be stimulated by early storage at 50° F. or higher and can be observed in as short a time as 2 weeks. Late storage of the cheese at the higher temperature does not cause the defect to develop. The slits that develop are not typical of a gassy cheese but rather the rupturing of the milled curd particles. They differ from the mechanical openings in that the surface of the slits is smooth and glazed.

The open-texture defect has been observed and studied by a number of investigators. Sherwood *(11)* studied the defect in New Zealand and concluded the abnormality to be caused by a gas-producing lactobacilli; and, since some Cheddar cheese starter cultures contain *Leuconostoc citrovorum*, this, he concluded, might also be a cause of the trouble. Galesloot *(3)* confirmed Sherwood's findings, but he states that a rapid acid-producing culture eliminates the problem. Prouty and Golding *(10)* studied the effect of the associate organisms in vacuum-packed Cheddar cheese and they reported that greater loss of vacuum was observed with *L. dextranicum* than with *L. citrovorum*. Overcast and Albrecht *(6)* showed the causative organism to be *L. citrovorum* in the culture, and the defect did not develop when a pure strain of *Streptococcus lactis* was used. Price *(9)* in a recent article states the causative organism could be anaerobic *Clostridium butyricum* and recommends that at least 1.7% salt be in the finished cheese as a remedial measure.

One of the factors linked to a typical Cheddar cheese flavor has been the presence of small amounts of diacetyl and related compounds *(2)*. These compounds have been linked with the associate organisms found in a typical cheese culture. These organisms also have the ability to produce considerable amounts of gas, capable of causing the open-texture defect when rapid curing of the cheese was done at temperatures of 50° F. or higher in the early stages of storage. With the elevation of the temperature, the rate of growth of the organisms increases, causing the amounts of CO_2 to exceed the solubility and diffusibility from the cheese, thus causing pressures to develop that can be relieved only through the rupturing of the partially fused curd particles. The prob-

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[2] Data submitted by F. E. Ashe in partial fulfillment of the requirements for a Master of Science degree.

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lem, therefore, was to investigate a possible remedy for the development of the defect.

EXPERIMENTAL PROCEDURE

Mixed herd milk as received at the University of Tennessee Creamery was used for the manufacture of the cheese unless otherwise specified. The milk was standardized to a casein-fat ratio of 0.70 through the addition of skimmilk, pasteurized at 144° F. for 30 minutes, cooled to below 50° F., and transferred to 50- or 100-gal. cheese vats. The cheese was made according to the method of Overcast *et al. (7)* unless otherwise specified. All of the cheese was placed in Young American style hoops, pressed overnight at 15 lb. pressure on the gauge of the Damrow hydraulic cheese press type H, and stored at 40°, 50°, and 58° F. After a minimum of 3 weeks the cheese was examined for slit-openness. This examination was made by removing plugs from each lot of cheese, stored at the three temperatures, with a cheese trier and examining it under natural light. The gas-produced slits differed from the common mechanical openings in that the surfaces of the slits were smooth, giving a glazed appearance. In the cheese with one or less slits per plug the defect was called very slight; that with 2-4 slits was called slight; that with 5-8 slits was called moderate; that with 8-12 slits was called distinct, and that with a greater number of slits was called very distinct.

The cheese was analyzed for nitrogen content *(5)*, for fat by the Babcock method, for moisture by drying under vacuum, and for salt *(14)*. Bacterial counts of the raw and pasteurized milk were made according to the *Standard Methods for the Examination of Dairy Products (1)*.

RESULTS AND DISCUSSION

Since the farms producing the manufacturing grade milk in this area practice spring freshening and the slit-openness texture was most serious during the fall and winter months, variations in salt composition of the milk within the extremes of the lactating period were investigated. Sommer *(12)* states that the calcium and magnesium content of milk increases during the last third of the lactation period and that the citric acid is highest when cows receive pasture feeds. Greenberg *(4)* has found calcium citrate to be soluble in water but not ionizable; therefore, it is possible that the calcium ions are not as available in milk during the pasture feeding periods as during the fall or winter months. According to the work of Van Slyke and Bosworth *(13)*, the calcium ions must be removed before monobasic paracasein would be soluble in a 5% salt solution. With these factors in mind it was concluded that whereas calcium ions are necessary for the formation of the typical cheese curd, excessive amounts might be detrimental to the proper fusing of the curd into a single mass. Therefore, it might be easier for the gas produced during the early stages of cheese ripening to rupture the partially fused curd particles in the finished cheese.

One lot of 200 gal. of milk was pasteurized and distributed in the four vats in the following amounts: 80 gal. in the 100-gal. vat and 40 gal. in each

of the three 50-gal. vats. Calcium chloride was dissolved in water and added to the vats in the following amounts: Vat No. 1, control; vat No. 2, 0.005%; vat No. 3, 0.01%; and vat No. 4, 0.015% of the milk. In the second lot of milk, the amounts of $CaCl_2$ added to the milk were increased to 0.01, 0.05, and 0.10%. The results of this work showed no relationship to the development of the abnormality in spite of the marked increase in calcium content.

Three lots of milk were obtained from the University of Tennessee herd, one lot from cows lactating less than 8 months and the remainder from cows lactating more than 8 months. Milk from cows in early lactation was used as the control and milk from cows in late lactation was divided between two 50-gal. vats. All of the milk was pasteurized in the vats at 144° F. for 30 minutes. To one of the vats containing milk from cows in late lactation was added 0.01% anhydrous citric acid. The cheese produced from all lots of milk showed no essential differences in the degree of slit-openness defect. These experimental results seemed to indicate that the stage of lactation on the salts of milk had no effect upon the development of the defect.

Thus far University of Tennessee herd milk had been used. The fat test of the milk averaged 3.8%. After this period the milk was obtained from predominately Jersey breed herds and more nearly represented the type of milk used by the cheese industry of the state. The average fat of this milk was 4.7%. When the U. T. milk was used it was difficult to produce the defect, but when the latter milk was used it was difficult to inhibit the defect.

The next phase of the study was directed toward variations in the making procedure. Many commercial cheese plants in the area have been using higher temperatures of pasteurization in order to get a more effective kill of undesirable microorganisms. One lot of milk was divided between the four experimental cheese vats and pasteurized at 145°, 150°, 155°, and 160° F., respectively, with a holding time of 30 minutes. Immediately after the milk was cooled to the setting temperature, the culture was added. The results showed the heat treatment of the milk had no effect on the control of the slit-openness in the cheese.

Since the slow cooking method *(7)* had been used in the making of the cheese up to this time, it was necessary to determine if the method of cooking the cheese curd had any effect on the development of slit-openness. In this experiment Price's schedule *(8)* was compared with the slow, low-heating method developed at the University of Tennessee. Eight trials with four commercial starters plus a pure culture of *S. lactis* were conducted. The results showed that neither the cooking procedure nor the commercial starters used had any effect upon the control of slit-openness in the cheese. The pure culture organism of *S. lactis* did not produce the defect. Since the slow low-heating method of cooking the curd reached the desired acidity 45 to 60 minutes earlier than the more conventional procedure *(7)*, it was concluded that the rate of acid production under these conditions was not significant.

The next factor studied was the variation in acidity at the time of milling. Four vats of curd were allowed to develop acid up to 0.35, 0.40, 0.45, and 0.50%, respectively, before they were milled. The results showed that the degree of

acid development before the curd was milled had no effect upon the development of slit-openness.

Varying the amount of salt added to the milled curd was next tried in an attempt to control the slit-openness defect. In the first trial, salt was added to four vats of cheese curd at the rate of 2.00, 2.50, 3.00, and 3.50 lb. of salt per 1,000 lb. of milk. At the level of 3% or higher, the defect did not occur. Four additional trials were run in which the amounts of salt were reduced to 2.25, 2.50, 2.75, and 3.00 lb. per 1,000 lb. of milk. The results are shown in Table 1

TABLE 1

The influence of increased salt on the development of slit-openness in Cheddar cheese

Lot No.	Salt per 1,000 lb.	Development of defect[a]		% salt
		40° F.	58° F.	
	(lb.)			
1	2.00	×	××	1.58
	2.50	–	×	1.68
	3.00	–	–	1.99
	3.50	–	–	2.16
2	2.25		××	1.25
	2.50		×	1.27
	2.75		×	1.58
	3.00		–	1.45
3	2.25	Mechanical	××××	1.21
	2.50	opening	××	1.48
	2.75		××	1.64
	3.00		–	1.66
4	2.25	×	××	1.41
	2.50	–	×	1.46
	2.75	–	–	1.48
	3.00	–	–	1.68
5	2.25	–	××	1.38
	2.50	–	×	1.58
	2.75	–	–	1.58
	3.00	–	–	1.78

[a] – No evidence of slits
× Very slight evidence of slits
×× Slight evidence of slits
××× Moderate evidence of slits
×××× Distinct evidence of slits
××××× Very distinct evidence of slits

along with the analysis of the percentages of salt in the finished cheese. Variations in the amounts of salt added to the milled curd showed that the defect could be controlled. In the 20 vat-lots of cheese in this series of experiments, the slit-openness defect was not found in any lot containing 1.70% salt or more.

A possible explanation of the seasonableness of the defect may be related to overstandardization of the making procedure. If the amount of salt added to the milled curd is not increased with the higher solids of the milk produced during the fall and winter months and if the amount of salt is already marginal during the spring and summer months, the defect will develop. The amount of salt in the finished cheese should be at least 1.70%.

Another factor to be considered might be the relationship of the acid-producing organisms to the gas-producing associate organisms in a commercial

culture. Overcast and Albrecht *(6)* have shown that a pure culture of *S. lactis* did not produce the defect. The addition of the associate organism *L. citrovorum* with the pure culture did cause the defect to develop, and when the associate organisms were added to two commercial cultures, the defect was enhanced. During the warmer periods of the year it may be particularly difficult in many cheese plants to keep the incubation temperatures of the bulk starters at 70-72° F. Even slightly higher temperatures result in a marked reduction in the growth of the *L. citrovorum* organism and the defect may not develop even when the amount of salt in the cheese is below 1.60%. The added salt in the cheese may retard the growth of the organisms or improve the fusibility of the curd particles so that the gas does not rupture the curd particles.

SUMMARY

The salts in milk as related to the period of lactation had no effect upon the development of the seasonableness of the open-texture defect. Variations in the pasteurization temperatures of the cheese milk, cooking procedures, and acidity of the curd at the time of milling had no effect upon the control of the defect. When the finished cheese contained 1.60 to 1.70% salt, the defect was materially minimized.

REFERENCES

(1) American Public Health Association. *Standard Methods for the Examination of Dairy Products*, 9th ed. New York. 1948.

(2) Calbert, H. E., and Price, W. V. A Study of the Diacetyl in Cheese. I. Diacetyl Content and Flavor of Cheddar Cheese. *J. Dairy Sci.*, **32**: 515. 1949.

(3) Galesloot, T. E. An Early Gas Defect in Cheese Caused by *Betacoccus (Leuconostoc)* Species. *Neth. Milk Dairy J.*, **4**: 274. 1950.

(4) Greenberg, D. M. *Advances in Protein Chemistry*, M. L. Anson and J. T. Edsall, 2nd ed., Vol. I. Academic Press, Inc., New York. 1944.

(5) Markley, K. S., and Hann, R. M. A Comparative Study of the Gunning-Arnold and Winkler Boric Acid Modification of the Kjeldahl Method for the Determination of Nitrogen. *J. Assoc. Offic. Agr. Chemists*, **8**: 455. 1925.

(6) Overcast, W. W., and Albrecht, T. W. Gas Production in Cheddar Cheese. *J. Dairy Sci.*, **35**: 554. 1952.

(7) Overcast, W. W., Jarman, E. R., and Albrecht, T. W. Influence of Rate and Temperature of Cooking on the Time Required to Manufacture Cheddar Cheese from Pasteurized Milk. *J. Dairy Sci.*, **36**: 757. 1953.

(8) Price, W. V. Cheddar Cheese from Pasteurized Milk. Wis. Agr. Expt. Sta., *Bull.* 464, rev. June, 1945.

(9) Price, W. V. Open Texture or Late Gas Defect in Ripening Cheese. *Milk Products J.*, **45** (1): 22. 1954.

(10) Prouty, C. C., and Golding, N. S. The Action of the Associate Starter Organisms in American Cheddar Cheese. *J. Dairy Sci.*, **29**: 495. 1946.

(11) Sherwood, I. R. The Relation of Certain Lactic Acid Bacteria to Open Texture in Cheddar Cheese. *J. Dairy Research*, **10**: 326. 1939.

(12) Sommer, H. H. *Market Milk and Related Products*, 2nd ed., H. H. Sommer, Madison, Wis. 1948.

(13) Van Slyke, L. L., and Bosworth, A. W. Chemical Changes in the Souring of Milk. N. Y. (Geneva) Agr. Expt. Sta., *Tech. Bull.* 48. 1916.

(14) Wilster, G. H., Price, W. V., Morris, A. J., Goss, E. F., and Sanders, G. P. Determination of Fat, Moisture, and Salt in Hard Cheese. *J. Dairy Sci.*, **20**: 27. 1937.

LIMA BEAN SILAGE FOR DAIRY CATTLE[1,2]

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The production of lima beans is an important agricultural enterprise in various sections of the United States. A considerable quantity of vines and empty pods result each year from the harvesting of the beans. Some of this residue is fed to livestock, primarily as silage; some is spread back on the crop land, which is a questionable procedure as far as disease and insect pests are concerned; and some is not utilized in any useful manner.

The value of lima bean silage as a livestock feed has not been reported. In two reports from the U. S. Department of Agriculture *(3, 5)* the digestibility by sheep of one lot each of dried pea vines and dried lima bean vines was compared. There was very little difference in dry matter digestibility (63.3 and 64.8%, respectively). The apparent digestibility of the crude protein of dried pea vines was greater than that of dried lima bean vines (64.7 and 57.0%, respectively). The crude fiber of the lima bean vines was apparently digested to a greater degree than that of pea vines (60.9 and 54.9%, respectively). The sheep fed lima bean vines either lost or barely maintained body weight; those fed pea vines gained in weight. The pea vines were more palatable, resulting in a larger consumption of them. This may account, at least in part, for the difference in growth of animals fed the two feeds.

Investigations of the digestibility and the value of lima bean silage as feed for dairy cows are under way at this station. The following is a report of the results obtained during the first 2 years of these investigations.

EXPERIMENTAL PROCEDURE

Lactation studies. During each of the winters 1952-53 and 1953-54 six Holstein cows were divided into two groups of three cows each. The groups were as nearly alike as possible in level of milk production, stage of lactation, and age. Each year rations consisting of mixed hay, concentrates, and either lima bean vine silage or corn silage were fed in a reversal type experimental design. Each year one group of three cows was fed lima bean vine silage, and the second group received corn silage. At the end of 6 weeks the groups were reversed for a second 6-week period.

Both silages were fed at the rate of 30 lb. per day per cow; concentrates were fed according to production[4] (based on Morrison's *(4)* recommendations

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[2] The section dealing with digestibility is taken from the degree with distinction thesis presented by the junior author to the University of Delaware, 1954.

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[4] In 1952-53 the concentrate allowance was redetermined every 2 weeks. In 1953-54 the concentrate allowance was based upon the production prior to the start of the experiment; then it was arbitrarily reduced 0.3 lb. per day at the beginning of each succeeding experimental week.

for cows not on pasture receiving 2 lb. of hay equivalent per 100 lb. of body weight), and hay was fed ad libitum. In 1953-54 the cows fed lima bean silage were fed 1.5 lb. per day additional concentrates in an attempt to compensate for the grain in the corn silage.

The cows had been fresh at least 6 weeks, with the exception of No. 281. In 1952-53 this cow had calved 31 days prior to the beginning of the experiment. The freshening dates are given in Table 1.

TABLE 1
Experimental animals

Herd No.	Date freshened	Initial body weight
1952-53		*(lb.)*
282	July 15, 1952	1,392
303	Aug. 25,1952	1,472
275	June 20, 1952	1,423
10	July 26, 1952	1,378
281	Oct. 5, 1952	1,392
292	April 21, 1952	1,498
1953-54		
15	June 19, 1953	1,374
40	Sept. 22, 1953	1,420
292	June 25, 1953	1,459
39	Sept. 28, 1953	1,198
13	June 6, 1953	1,360
275	June 16, 1953	1,438

Milk production was determined daily. A composite evening and morning sample from each cow was tested for butterfat once each week. Body weights were determined on three consecutive days at the beginning and at the end of each experimental period.

The experimental periods covered the followings dates:

1952-53 Period I—Nov. 5-Dec. 17, 1952
Period II—Dec. 17, 1952-Jan. 28, 1953
1953-54 Period I—Nov. 19-Dec. 31, 1953
Period II—Dec. 31, 1953-Jan. 19, 1954

The hays fed were variable in botanical composition and quality, but both groups of cows received the same kind of hay each day.

The concentrate mixture fed was made up of 50% home grown grains (mainly corn and cob meal) mixed with wheat bran, citrus pulp, and cottonseed meal to make a 16% total protein content.

The corn silage was made from well-eared hybrid corn. The lima bean vine silage was put in an upright silo at the Delaware Agricultural Experiment Station. The material used consisted of the vines and empty pods obtained directly from the bean viner. These were hauled by tractor trailer about 30 miles to the silo where they were chopped and blown in. In spite of thorough packing and a wet covering of straw, there was considerable spoilage. The spoilage was due largely to leaks in the silo and to the small amount of material which was placed in a large diameter silo (16 ft.).

Digestion trials. Digestion trials were conducted during January, 1954, in metabolism crates with two Holstein bulls[5] weighing approximately 425 lb. On December 25 the bulls were changed from a grain-hay ration to a ration of hay alone. On January 8 lima bean silage was introduced and the amount was increased gradually until the bulls were receiving only lima bean silage. An amount which would be cleaned up readily was determined, and an 8-day preliminary period began January 14. The intake was kept constant during the preliminary period and a 10-day collection period. Body weights were determined on three successive days at the beginning and at the end of the collection period. The change in weight covers a 9-day period because weights taken the day following the collection period were greatly different from those of the preceding 2 days because of the change in ration. For this reason weights on the eighth, ninth, and tenth days were averaged, instead of the ninth, tenth, and eleventh days.

The animals were fed twice daily. At each feeding, random samples of silage were taken. The samples from the various feedings were composited for analysis. Moisture and crude protein determinations were made on fresh samples. Ether extract, crude fiber, and ash were determined on samples which had been dried at about 60° C., then allowed to come to an air dry condition, and ground for analysis. The feces and urine were weighed and sampled daily. The methods of analysis used were: moisture—toluene distillation *(2);* crude protein, ether extract, crude fiber, ash and nitrogen-free extract—proximate analysis *(1).*

TABLE 2

Composition of silages fed to milking cows

	Moisture	Crude protein	Ether extract	Ash	Carbohydrates[a]
	(%)	*(%)*	*(%)*	*(%)*	*(%)*
Lima bean silage					
1952-53	74.9	3.22	0.87	4.83	16.19
1953-54	70.5	3.40	0.74	3.22	22.30
Corn silage					
1952-53	63.1	2.74	0.92	1.68	31.56
1953-54	65.9	2.93	1.22	1.88	28.04

[a] A separation of carbohydrates into crude-fiber and nitrogen-free extract fractions has no real significance in forage digestion by ruminants *(6).* These are therefore listed together. The crude fiber values were 7.8, 10.4, 9.1, and 7.8, respectively.

RESULTS AND DISCUSSION

Lactation studies. The chemical composition of the silages fed to the lactating cows is given in Table 2. The dry matter content of the lima bean silages was less than that of the corn silages. The crude protein was appreciably higher in

[5] Three bulls were started but one was discontinued because of winter scours and a shortage of the lima bean silage.

the lima bean silage, and the ash content was about double that of the corn silage. The high ash content was due, in large part, to the fact that the lima bean crop included the roots as well as the above-ground portions. In studies with ruminants a division of the carbohydrates of roughages into crude fiber and nitrogen-free extract fractions has no real meaning in determinations of digestibility *(6)*. The digestibility of the two fractions is very similar with most roughages; therefore, in this study they are combined.

The feed consumption, milk production, and body weight changes during each period are given in Table 3. Because of an unexpectedly large amount

TABLE 3

Feed consumption and milk production of cows fed lima bean and corn silages

	Silage	Hay	Concentrates	Estimated TDN intake[a]	FCM[b]
	(lb.)	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*
Lima bean silage					
1952-53	25.8	27.0	13.7	27.4	37.4
1953-54	25.9	30.0	15.8	30.5	43.0
Mean	25.8	28.5	14.8	28.9	40.2
Standard error	±0.85	±1.24		±0.92	±2.22
Corn silage					
1952-53	28.2	22.2	13.7	26.5	39.7
1953-54	28.1	26.1	14.3	28.9	42.0
Mean	28.1	24.2	14.0	27.7	40.8
Standard error	±0.65	±1.28		±0.89	±2.40

[a] TDN intake estimated as follows: concentrate mixture, 75%; lima bean silage, 14%; corn silage, 18%; and hay, 50%.
[b] FCM calculated by Gaines' formula (0.4 × milk + 15 × fat).

of spoilage, Period II in the 1953-54 season was only 19 days long. There were refusals of both silages, but the refusals of lima bean silage were consistently greater than those of corn silage, resulting in a significantly larger intake of the latter (odds > 99:1). The groups fed lima bean silage consumed significantly more hay (odds > 99.1). The additional concentrate allowance given cows fed lima bean silage in 1953-54 explains the difference in concentrates consumed. The estimated total digestible nutrients intake was greatest for the lima bean groups. This was in part due to the increased concentrates fed, but the greatest difference was due to the larger hay consumption by those fed lima bean silage.

The milk production was not significantly different between the two groups either in actual production or in fat-corrected milk. Likewise, body weight changes were not significantly different.

The lima bean silage fed in this experiment was not as palatable as corn silage. There were varying amounts of grit present, owing to the inclusion of roots in the harvesting process. This undoubtedly had some effect on the palatability of the silage. If lima bean silage is to be fed to lactating cows, it must

be kept in mind that the beans have been removed, whereas corn silage contains a considerable amount of grain. In this study the lessened quantity of nutrients in the lima bean silage was more than made up by an increased hay intake.

Lima bean silage can be successfully fed to milking cows, but because of decreased palatability it probably cannot be fed in as large quantities as corn silage.

Digestion trials. The weight gains and the amounts of nitrogen retention, silage intake, and feces and urine voided are given in Table 4. The bulls gained

TABLE 4

Daily weight gains, forage intake, feces and urine voided, and nitrogen retained by Holstein bull calves

	Bull 1	Bull 2
Forage intake[a] *(g.)*	14,740	16,420
Feces voided[a] *(g.)*	7,786	8,560
Urine voided[a] *(g.)*	3,523	4,156
Initial body weight[b] *(lb.)*	405	447
Average daily gain *(lb.)*	1.08	1.33
Nitrogen retained *(g.)*	5.59	0.91

[a] Wet basis.
[b] Average of 3 days.

an average of 1.21 lb. per day. Both bulls were in positive nitrogen balance; however, bull 1 stored 55.9 g., whereas bull 2 stored only 9.1 g. of nitrogen. Only a small portion of the increase in weight was due to an increase in protein tissues.

Chemical composition of the silage and feces is given in Table 5, as well as

TABLE 5

Composition of forage and feces and apparent digestibility of lima bean silage

	Dry matter	Crude protein	Ether extract	Carbohydrates	Ash
	(%)	*(%)*	*(%)*	*(%)*	*(%)*
As fed	23.0	2.52	0.70	17.33	2.45
Moisture-free	100.0	10.93	3.05	75.39	10.63
Feces (dry basis)					
Bull 1	100.0	13.30	3.59	65.00	18.11
Bull 2	100.0	14.39	3.87	63.19	18.55
Digestibility					
Bull 1	53.0	41.5	44.7	59.6	——
Bull 2	53.6	40.7	41.6	60.8	——
Average	53.3	41.1	43.2	60.2	——

the apparent digestibility of the various fractions. The apparent digestibility of the crude protein was much lower than that of the carbohydrates. This may be due, at least in part, to the low level of protein in the ration. Under these conditions much of the crude protein in the feces is of metabolic rather than food origin.

The apparent digestibility of the ether extract also was lower than that of the major fraction, the carbohydrates. In forages much of the material extracted by ether is not true fat but rather consists of pigments and waxes, which are relatively indigestible.

The dry matter digestibility of lima bean silage compares well with that of such forages as alfalfa hay, timothy hay, and others listed by Morrison *(4)*. The carbohydrates were digested to the extent of approximately 60%.

SUMMARY

A comparison of the value of lima bean silage and corn silage for lactating cows was made during the winters of 1952-53 and 1953-54. Each year six registered Holstein cows were fed in a single reversal experimental design. Corn silage was consumed more readily than the lima bean silage, and significantly more hay was consumed by the groups on lima bean silage. The milk production was not significantly different between cows fed the two silages.

The apparent digestibility of lima bean silage was determined in a conventional digestion trial with two Holstein bulls weighing approximately 425 lb. The dry matter was 53.3% digestible. The apparent digestibility of crude protein was 41.1%; of ether extract, 43.2%; and of carbohydrates, 60.2%.

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REFERENCES

(1) Association of Official Agricultural Chemists. *Official and Tentative Methods of Analysis.* 6th ed., p. 404. 1945.

(2) Bidwell, G. L., and Sterling, W. F. Preliminary Notes on the Direct Determination of Moisture. *Ind. Eng. Chem.*, **17** (1): 147. 1925.

(3) Davis, R. E., Miller, C. O., and Lindahl, I. L. Apparent Digestibility by Sheep of Lignin in Pea and Lima-Bean Vines. *J. Agr. Research*, **74** (9 & 10): 285. 1947.

(4) Morrison, F. B. *Feeds and Feeding.* 21st ed., p. 1086. The Morrison Publishing Co., Ithaca, N. Y. 1949.

(5) Phillips, Max, Miller, C. O., and Davis, R. E. Composition and Apparent Digestibility of the Carbohydrate and Other Constituents of Pea and Lima Bean Vines when Fed to Sheep. *J. Agr. Research*, **73** (5): 177. 1946.

(6) Richards, C. R., and Reid, J. T. The Digestibility and Interrelationships of Various Carbohydrate Fractions of Pasture Herbage and a Resolution of the Components of Crude Fiber and Nitrogen-Free Extract. *J. Dairy Sci.*, **36**: 1006. 1953.

PRELIMINARY FERTILITY RESULTS WITH FROZEN BOVINE SPERMATOZOA

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Freezing and storing of extended bull semen in single breeding vials or ampules seems to offer considerable opportunity to reduce the wastage of the spermatozoa that now occurs with unfrozen semen. But to take advantage of this opportunity requires –79° C. storage facilities for the field technicians and the semen production and processing center. These facilities are an additional care and expense to both the central organization and the technician.

As an alternative, if semen could be frozen "concentrated" and stored at the bull stud until needed, then thawed and further extended as required, and shipped to technicians for use, as is now done with unfrozen semen, storage costs for frozen semen at the bull stud would be greatly reduced and those in the field eliminated. However, this procedure has inherent in it those inefficiencies of semen usage resulting from the unpredictable number of daily requests for service that technicians now experience with unfrozen semen.

To date, only limited data have been reported comparing the fertility of frozen and unfrozen bovine spermatozoa *(4, 5, 10, 12, 13, 14, 15)*, and none of these reports, so far as the authors can find, present fertility data on semen frozen and then thawed and used after 24 hours of storage at the conventional temperatures used for unfrozen semen. The experiment reported here was designed to compare the fertility of unfrozen and frozen spermatozoa from the same ejaculates of semen when the latter were either frozen "concentrated" and thawed at the bull stud or frozen in single breeding vials and thawed at the farm.

EXPERIMENTAL PROCEDURE

The pooled first and second ejaculates from each of two collection periods for three Holstein sires in the stud of the New York Artificial Breeders' Cooperative, Inc., were subdivided for processing and breedings as follows:

(a) Unfrozen control stored at 5° C. and used from 1 to 3 days old.
(b) Frozen "concentrated," thawed at central, extended to final volume, stored at 5° C., and used 24 to 60 hours later.
(c) Frozen in single breeding vials, stored 2 days at –79° C., thawed at the farm, and inseminated immediately.
(d) Frozen in single breeding vials, stored 103 days at –79° C., thawed at the farm, and inseminated immediately.

The semen was collected about 3 P.M., partly processed that same afternoon, and either shipped to field technicians or placed in –79° C. storage about 9 A.M.

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the following day. In general the prefreezing and freezing procedures embodied the recommendations of Polge and Rowson *(13, 14, 15)*, Dunn *et al. (4, 5, 6)*, and Miller and VanDemark *(11)*.

The extenders used and their composition are shown in Table 1.

TABLE 1

Composition of the buffers and extenders[a]

Extenders	Concentration of citrate, glycerol, and sulfanilamide in buffers			Proportion of egg yolk to buffer	Concentration of citrate, glycerol, and sulfanilamide in extenders[b]		
	C	SA	GL[c]	Y:B	C	SA	GL[c]
	(%)	*(%)*	*(%)*		*(%)*	*(%)*	*(%)*
2.9CSAY	2.9	0.6	—	1:1	1.45	0.3	—
2.9CY[d]	2.9	—	—	1:4	2.32	—	—
2.9CYGL[d]	2.9	—	17.5	1:4	2.32	—	14.0

[a] 2.9 refers to the per cent of sodium citrate dihydrate in the buffer. C = citrate; SA = sulfanilamide; GL = glycerol; Y = hen's egg yolk; B = buffer.

[b] Each extender contained 500 units each of penicillin and streptomycin per milliliter of extender.

[c] By weight, using a sp. gr. for glycerol of 1.25.

[d] Addition of the 2.9CYGL to the 2.9CY during the glycerolating process gave a final extender containing 7% glycerol by weight.

Unfrozen control semen. The freshly collected semen was pre-extended 1:4 in 30° C., 2.9CSAY extender *(1)* and cooled to 5° C. in 75 minutes according to the recommendations of Foote and Bratton *(8)*. After being cooled, it was further extended to 10×10^6 motile spermatozoa per milliliter with 5° C., 2.9CSAY extender and shipped to field technicians for breeding cows in the routine manner.

Semen frozen "concentrated." The spermatozoa to be frozen "concentrated" were pre-extended 1:4 with the nonglycerol containing 2.9CY extender at 30° C. and cooled to 5° C. in 75 minutes in the routine manner *(8)*. After cooling, more of this 2.9CY extender at 5° C. was added to adjust the number of motile spermatozoa to approximately 400×10^6 per milliliter. An equal volume of glycerol-containing extender, 2.9CYGL, then was added in 10 aliquots at 8-minute intervals to give 200×10^6 motile spermatozoa per milliliter of extender before freezing.

The spermatozoa were allowed to equilibrate in the 7% glycerol extender for a period of about 12 hours, and then were frozen. Freezing was done in an alcohol bath by adding finely cracked solid CO_2 in quantities sufficient to lower the temperature 0.8° C. per minute from 5° C. to –15° C. After –15° C. was reached, solid CO_2 was added as rapidly as possible, and the temperature was brought down to –79° C. in about 15 minutes. The total freezing time averaged approximately 40 minutes.

Immediately after being frozen, the "concentrated" semen was thawed in 5° C. water, and the per cent of motile spermatozoa was estimated. On the basis of these estimates it was further extended with 5° C., 2.9CY extender to give

10×10^6 motile spermatozoa per milliliter of extender. This semen then was packaged and shipped to the field technicians in the same manner as that for the unfrozen control semen. Approximately half of the technicians received the unfrozen control semen from each bull the first week, and the other half received the semen frozen "concentrated" and thawed and further extended at the bull stud. The following week the treatments for the two technician groups were reversed.

Semen frozen in single breeding vials. The portion of the fresh ejaculates to be frozen in single breeding vials was pre-extended and cooled in the same manner as the unfrozen control semen and the semen frozen "concentrated" using 30° C., 2.9CY extender. After being cooled, this pre-extended semen was made up to one-half of the required final volume with 5° C., 2.9CY, and at 5° C. an equal volume of the glycerol-containing extender, 2.9CYGL, was added in 10 equal portions at 8-minute intervals.

In order to have approximately 10×10^6 motile spermatozoa per milliliter of extended semen after freezing, the number before freezing was adjusted upward to compensate for the number that were expected to be killed during the freezing process. For example, if the average survival percentage of the spermatozoa, $\left(\frac{\text{per cent motile sperm after freezing}}{\text{per cent motile sperm in fresh semen}}\right)$, of a bull was 70 then, $\frac{10 \times 10^6}{0.70} = 14.3 \times 10^6$ motile spermatozoa, which was the number of motile spermatozoa needed in the extended semen prior to freezing.

In addition to this correction for anticipated spermatozoan losses during freezing, the vials[1] were filled with 1.1 ml. of the extended semen to allow for a loss of 0.1 ml. at the time it was withdrawn from the vial for insemination.

The vials were tightly corked, placed cork end up in freezing racks in the alcohol bath and frozen at the same rate as the semen frozen "concentrated." After freezing, the vials were transferred in 2 to 3 seconds into cellophane bags and stored in cracked solid CO_2.

These single breeding vials were transported to the field in a 1-gal., wide-mouth vacuum flask (Dewar). Within the vacuum flask the vials were held in a circular wire basket 3 in. in diameter with finely cracked solid CO_2 below and around them and a bag of solid CO_2 on top of them. The total amount of solid CO_2 in the flask was about 7 lb. and was enough to maintain a –79° C. temperature constantly for 3 to 4 days in the field. The Dewar flask, along with a wide-mouth pint thermos bottle in which to thaw the samples at 30° C. to 38° C. and a quart thermos bottle for holding hot water for thawing, was fitted into a carrying case for the technicians' convenience and to facilitate controlled thawing of the samples at the farm.

Four technicians, other than those using the semen frozen "concentrated" or the unfrozen control semen, and located within 2 hours driving distance of the bull stud, were chosen to make the inseminations with the single-breeding

[1] These were 4-ml., 75 mm. × 11 mm. polystyrene vials obtained from Celluplastic Corp., Newark, N. J.

vials thawed at the farm. Because the 1-day-old frozen semen was used during the light breeding season, these four technicians were requested to obtain as many breedings with frozen semen as possible, and they did not use the unfrozen control semen. The 103-day-old samples were used during the heavy breeding season by the same four technicians.

Fertility levels were determined from the number of first service cows not returning for reinsemination within 28 to 35 days and 60 to 90 days after insemination, and from actual calving reports obtained by means of a postal-card survey of the dairymen whose cows were bred with frozen semen.

RESULTS AND DISCUSSION

In Table 2 are data pertaining to the number and per cent of motile spermatozoa in the fresh unextended semen and the estimated number of motile spermatozoa per insemination at the time the semen was used for breeding. The larger number of motile spermatozoa in the single-breeding samples as compared to the control and the "concentrated" samples can be accounted for by the fact that more of the spermatozoa in these samples survived the freezing process than was originally estimated.

TABLE 2

Estimated numbers of motile sperm in the unfrozen and frozen extended semen at the time of insemination

		Fresh semen before extending		Estimated number of motile sperm per insemination ($\times 10^6$)			
						Frozen, single breedings	
Date	Bull	No. of sperm $\times 10^6$ per ml. semen	% motile sperm	Control semen unfrozen	Frozen "concentrated"	Stored 1 day	Stored 103 days
Aug. 25	1	1,523	60	8.3	7.5	9.5	8.1
Sept. 3	1	1,597	60	6.7	7.5	14.3	11.9
Aug. 26	2	1,761	60	8.3	7.5	11.9	8.3
Sept. 4	2	1,791	70	5.7	8.3	10.6	10.6
Aug. 27	3	1,202	74	8.1	8.3	12.3	13.5
Sept. 6	3	1,569	67	7.5	8.0	9.3	9.3
Average		1,574	65	7.4	7.8	11.3	10.3

Table 3 shows the percentage of motile spermatozoa in the unfrozen and frozen semen after varying periods of time in storage and after thawing. The survival percentages for the frozen spermatozoa at the time of thawing compared favorably with those for the control semen at the time most of it would have been used for insemination. Although the post-thawing survival percentages of the spermatozoa frozen "concentrated" were definitely lower than those for the unfrozen control semen, both showed similar rates of decline.

Table 4 shows the fertility of the unfrozen and frozen spermatozoa. Although the number of breedings to the semen frozen "concentrated" were limited, the 60- to 90-day per cent nonreturns were not encouraging. The 22.8 percentage units difference between the 60- to 90-day per cent nonreturns for the unfrozen

TABLE 3

Per cent of motile sperm in unfrozen and frozen semen during storage

Date of collection	Bull	Fresh unextended semen	Unfrozen control stored at 5° C.			Frozen concentrated, thawed and stored at 5° C.			Frozen in single-breeding vials	
			1 day	2 days	3 days	1 day	2 days	3 days	2 days	86-91 days
			% motile sperm							
Aug. 25	1	60	50	50	40	30	20	20	40	35
Sept. 3	1	60	50	50	40	30	30	20	60	50
Aug. 26	2	60	50	50	50	30	30	10	50	35
Sept. 4	2	70	40	40	20	40	40	20	50	50
Aug. 27	3	74	60	60	50	50	40	30	50	55
Sept. 6	3	67	50	50	40	30	30	20	50	50
Av. % motile		65	50	48	38	35	32	20	50	46
Av. % surviving			77	74	58	54	49	31	77	71

TABLE 4

Fertility of unfrozen and frozen bovine spermatozoa

Date of collection	Bull	Semen used unfrozen as control		Semen frozen concentrated, thawed at the bull stud		Semen frozen in single breeding vials and thawed at time of insemination			
						Stored 1 day at −79° C.		Stored 103 days at −79° C.	
		1st serv.	60-90 day % N.R.	1st serv.	60-90 day % N.R.	1st serv.	60-90 day % N.R.	1st serv.	60-90 day % N.R.
Aug. 25	1	106	74	91	58	9	67	24	83
Sept. 3	1	66	73	68	54	10	70	14	71
Aug. 26	2	59	58	62	47	7	57	21	86
Sept. 4	2	87	78	73	31	15	67	8	62
Aug. 27	3	117	81	103	52	9	89	14	71
Sept. 6	3	24	76	52	69	5	100	11	73
Total		459		449		55		92	
Average			74.5		51.7		72.7		77.0

control semen and the semen frozen "concentrated" was highly significant statistically, $P < 0.01$, and cannot be accounted for logically by the difference in the estimated number of spermatozoa inseminated, as given in Table 2.

The average 60- to 90-day per cent nonreturns for the 147 single-breeding samples thawed at the farm after storage for 1 and 103 days was 75.4, as compared to 74.5 for 459 breedings to unfrozen control semen. Because the average difference between these means was so small and because of the limited size of the sample no statistical test of significance was made.

The herds using frozen semen were surveyed and on the basis of 34 calving reports received out of the 55 first services to the 1-day-old frozen semen thawed at the farm there were 59% actual conceptions with 23 single live births and one set of twins. All calves were normal.

Although the fertility results obtained with the single breeding samples thawed at the farm were encouraging and better than most reported to date,

it is obvious that much more extensive fertility data must be obtained before the general use of frozen bovine semen can be recommended on the basis that it will give fertility results equal to unfrozen semen. However, the satisfactory fertility results obtained with this method of freezing semen and thawing at the farm and the recent reports by Cragle and Myers *(2)*, Erickson *et al. (7)*, Kinney and VanDemark *(9)*, and Saroff and Mixner *(16)* tend to give general support to the procedure. Additional field trials to better estimate the fertility of spermatozoa frozen and stored at –79° C. are in progress.

SUMMARY

The fertility of bovine spermatozoa frozen in a concentrated form (200×10^6 motile spermatozoa per milliliter of extender), thawed at 5° C. at the bull stud, further extended to approximately 10×10^6 motile spermatozoa per milliliter and used for breeding 24 to 60 hours later, was compared with that of semen frozen in single-breeding vials. The latter were thawed at the farm just prior to insemination. The split sample technique was used with two ejaculates from three different bulls. Prefreezing processing and freezing procedures were slightly modified from those reported by Polge *et al.* and Dunn *et al.* Unfrozen semen processed in the conventional manner was used for the control breedings. All semen was extended to provide 8 to 10 million motile spermatozoa per insemination, though estimates made later indicated that actual numbers varied between 4 and 14 million. The 60- to 90-day nonreturns to first services were as follows: unfrozen control, 459 services, 74.5%; frozen "concentrated," 449 services, 51.7%; frozen as single breeding samples and stored one day at –79° C., 55 services, 72.7%; frozen as single breeding samples and stored 103 days at –79° C., 92 services, 77.0%.

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REFERENCES

(1) Bratton, R. W., Foote, R. H., Musgrave, S. D., and VanDemark, N. L. Livability and Fertility of Bovine Spermatozoa in Different Diluents. *J. Dairy Sci.*, **32**: 604. 1949.

(2) Cragle, R. G., and Myers, R. M. Effects of Levels of Sodium Citrate, Glycerol, and Equilibrating Time on Recovery of Bovine Spermatozoa after Storage at –79° C. *J. Dairy Sci.*, **37**: 652. 1954.

(3) Dunn, H. O., and Hafs, H. D. Extenders and Techniques for Freezing Bovine Spermatozoa. *J. Dairy Sci.*, **36**: 577. 1953.

(4) Dunn, H. O., Hafs, H. D., Young, G. F., Buckner, P. J., Conrad, E. O., Larson, G. L., and Willett, E. L. Personal communication. Wisconsin Scientific Breeding Institute and The American Foundation for the Study of Genetics. Madison, Wis. 1954.

(5) Dunn, H. O., Larson, G. L., and Willett, E. L. Preliminary Breeding Results with Frozen Semen. *J. Dairy Sci.*, **36**: 578. 1953.

(6) Dunn, H. O., Larson, G. L., and Willett, E. L. The Effects of Freezing Bovine Spermatozoa in Extenders Containing Antibacterial Agents. *J. Dairy Sci.*, **36**: 728. 1953.

(7) ERICKSON, W. E., GRAHAM, E. F., AND FREDRICK, E. C. The Effect of Antibiotics, Levels of Glycerol and Rates of Freezing on Revival Rate of Bovine Spermatozoa in Yolk–Citrate and Milk Extenders. *J. Dairy Sci.*, **37**: 651. 1954.

(8) FOOTE, R. H., AND BRATTON, R. W. The Fertility of Bovine Semen Cooled with and without the Addition of Citrate–Sulfanilamide–Yolk Extender. *J. Dairy Sci.*, **32**: 856. 1949.

(9) KINNEY, W. C., JR., AND VANDEMARK, N. L. The Effect of Yolk and Citrate Levels and Stage of Maturity on the Survival of Bull Sperm at Sub-Zero Temperatures. *J. Dairy Sci.*, **37**: 650. 1954.

(10) MACPHERSON, J. W., AND HENDERSON, J. A. Low Temperature Preservation of Bull Semen. Paper presented at the Convention of the Am. Vet. Med. Assoc., Toronto, Canada. July, 1953.

(11) MILLER, W. J., AND VANDEMARK, N. L. The Influence of Glycerol Level, Various Temperature Aspects, and Certain Other Factors on the Survival of Bull Spermatozoa at Sub-Zero Temperatures. *J. Dairy Sci.*, **37**: 45. 1954.

(12) O'DELL, W. T., AND ALMQUIST, J. O. Techniques for Freezing Bull Spermatozoa in Heated Milk and Preliminary Breeding Results. *J. Dairy Sci.*, **37**: 652. 1954.

(13) POLGE, C., AND ROWSON, L. E. A. Fertilizing Capacity of Bull Spermatozoa After Freezing at –79° C. *Nature*, **169**: 626. 1952.

(14) POLGE, C., AND ROWSON, L. E. A. Results with Bull Semen Stored at –79° C. *Vet. Record*, **64**: 851. 1952.

(15) ROWSON, L. E. A., AND POLGE, C. Storage of Bull Semen at –79° C. and Fertility Results for Up to 12 Months. *Vet. Record*, **65**: 677. 1953.

(16) SAROFF, J., AND MIXNER, J. P. The Relationship of Diluter Composition and Glycerol Equilibration Time to Survival of Bull Spermatozoa After Freezing to –75° C. *J. Dairy Sci.*, **37**: 651. 1954.

AUREOMYCIN[1] CONTENT, BACTERIAL DEVELOPMENT, STARTER ACTIVITY, AND CHEESE QUALITY OF MILK FROM COWS FED AN AUREOMYCIN SUPPLEMENT[2]

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It has been reported by Haq *et al. (3)* and Rusoff and Haq *(6)* that the milk from cows fed aureomycin in amounts of 130 mg. daily showed normal bacterial development during holding for 12 hours at 35° C. All such milk developed lactic acid and produced a normal acid curd. Presumably, the antibiotics either were not passed into the milk or were present in too low concentrations to affect bacterial development. Similar observations were made by Loosli and Warner *(4)*, who found no aureomycin in milk of cows fed 700 mg. of the antibiotic daily for 10 days. Also, they found that feeding 500 mg. per day for 6 days did not affect cheese starter activity in the milk. Bradfield *et al. (2)* found little inhibition of starter activity when aureomycin was added at less than 0.25γ per milliliter of milk. Olson *et al. (5)* reported that aureomycin added to pasteurized milk in a concentration of 0.2γ per milliliter had no preservative effect. Some types of bacteria were suppressed but were compensated for by the growth of other types. A study on the feeding of aureomycin to dairy cows *(1)* provided an opportunity to investigate further the possible elimination of the antibiotic into the milk. Examinations were made to determine if the milk had an inhibitory effect on bacterial development or if it affected cheese manufacture and quality. Also, the milk was assayed for aureomycin content.

METHODS

The conditions of feeding the aureomycin to the cows were described by Bartley *et al. (1)*. Seven cows in Group A fed aureomycin during Period I received no aureomycin during Period II and again received aureomycin during Period III. Seven cows in Group B received no aureomycin during Period I, received aureomycin during Period II, and received no aureomycin during Period III. Six cows in Group C were not fed aureomycin during any of the periods and served as controls. The experimental periods were 6 weeks.

Lederle's Aurofac 2A was fed once a day in the grain in amounts calculated to supply 32 mg. of aureomycin for each 100 lb. body weight. The rate of feeding was equivalent to an average of 390 mg. per cow daily.

Individual milk samples for this study were obtained during the fifth and sixth week of Period II and during the second and third week of Period III.

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[1] The trademark of Lederle Laboratories Div., American Cyanamid Co., Pearl River, N. Y., for the antibiotic chlortetracyline.

[2] Contribution No. 228, Dept. of Dairy Husbandry, Kansas Agricultural Experiment Station, Manhattan.

Hence, in each period the cows involved were those currently receiving aureomycin, those that had previously received the antibiotic, and those that had never received aureomycin. Samples were obtained in milk bottles sanitized in the milk plant bottlewasher, but not otherwise sterilized. The milk samples were iced and returned to the laboratory.

Samples of milk for bacteriological studies were refrigerated until making the initial bacterial counts and then subsequently held at room temperature (70-80° F.). The first plating was made within 20 hours of the time the samples were taken, and the second and third platings were made 18 and 24 hours later, respectively. Standard Plate Count methods were employed with tryptone glucose extract agar. General observations were made for rate and type of defect development in the samples. In studying acid development, samples (140 ml.) of milk from each cow were laboratory pasteurized shortly after collection and held refrigerated over night. One per cent active cheese starter was then added to the samples, which were warmed to 88° F. and incubated at that temperature. Acid development in the milk was determined by titrating 9-ml. portions against 0.1 *N* NaOH at the start and after 4, 6, and 24 hours.

In the cheese studies each trial consisted of two vats of Cheddar cheese; one made from milk of cows that had never received aureomycin and the other from milk of cows currently receiving the antibiotic. The initial acidity of each lot of milk and the acid in the curd at milling time were compared. The cheeses were held in storage for 3 months, then scored for flavor, body, and texture by a panel of cheese judges.

During the fourth week of the second period of the feeding trials, a composite sample of milk from cows previously fed aureomycin and a composite from those currently receiving aureomycin were submitted to Lederle Laboratories for estimation of antibiotic content.

RESULTS

Bacterial development in raw milk. The feeding of aureomycin to cows had no definite effect on the total numbers of bacteria that developed in the raw milk as shown by bacterial plate counts. Results from the four trials, involving 216 counts on 72 samples, are summarized in Table 1. In Trial 1, the average bacterial counts (antilog. of log. average) suggest a slight inhibition in samples from the group of cows that were currently receiving aureomycin and in the group that had received aureomycin 5 weeks previously. Also, in Trial 4 some inhibiting effect on bacterial growth seemed evident in the milk from the cows fed aureomycin, as indicated by average bacterial counts (antilog. of log. average). However, graphical analyses of the counts on the milk from individual cows during each of the four trials showed no clear-cut effect due to feeding aureomycin. There was considerable variability in counts from cow to cow, with no apparent significant difference in mean counts due to treatments. Also, there was no particular association between the initial counts and the 24-hour counts. In Trial 1, the second series of counts was made after 6 hours instead of 18 hours,

TABLE 1

Bacterial development in raw milk (70-80° F.) from cows fed an aureomycin supplement

Period	Trial	Cow group	Treatment	Av. bacterial count (antilog. of log av.)/ml. milk[a]		
				Initially	After 18 hr.	After 24 hr.
2	1	A	5th wk. after start of aureomycin feeding	3,000	4,500[b]	7,455,000
		B	5th wk. after cessation of aureomycin feeding	2,727	8,017[b]	9,350,000
		C	Never fed aureomycin	6,414	16,950[b]	13,850,000
	2	A	6th wk. after start of aureomycin feeding	1,442	4,286,000	39,590,000
		B	6th wk. after cessation of aureomycin feeding	1,480	3,081,000	34,670,000
		C	Never fed aureomycin	1,757	2,070,000	27,690,000
3	3	A	2nd wk. after cessation of aureomycin feeding	3,004	219,500	3,820,000
		B	2nd wk. after start of aureomycin feeding	1,153	104,800	2,373,000
		C	Never fed aureomycin	1,279	135,600	2,147,000
	4	A	3rd wk. after cessation of aureomycin feeding	2,454	132,200	1,999,000
		B	3rd wk. after start of aureomycin feeding	2,977	58,770	867,500
		C	Never fed aureomymin	3,909	184,600	2,033,000

[a] Average counts on individual samples from 6 cows, sampled once during each trial..
[b] Counts made 6 hr. after the initial count, instead of 18 hr. after.

hence these counts were lower. A higher room temperature during the holding period probably contributed to high counts in Trial 2 at the 18- and 24-hour periods.

Acid development. The average increase in titratable acidity in the starter-inoculated milk from all cows currently receiving aureomycin was 0.626% compared with 0.610 and 0.649%, respectively, in the milk from cows that had received aureomycin previously and in the milk from those that had received no aureomycin (Table 2). There was considerable variation in the rate of acid development and the final titratable acidity of the milk from individual cows in all three groups.

Cheese quality. The results on the acid development during cheese making and the score of the cheese made from four lots of milk from cows that had received no aureomycin and from those currently receiving aureomycin are recorded in Table 3.

The rate of acid development in the curd was about the same for milk from the two groups of cows. The average acidity at milling was 0.42% in the curd from milk from the cows that had received no aureomycin and 0.44% in the curd from milk from the cows receiving aureomycin.

The average flavor score for the four cheeses made from the milk from cows in the control group was 38.9 points, the same as the average score for the cheese made from the milk from cows receiving aureomycin. There was only 0.25 of a point difference in the average body and texture score of all cheese made from the milk from the two groups of cows.

TABLE 2

Effect of feeding cows aureomycin on acid development in pasteurized milk inoculated with 1% starter and incubated at 88°F.

Period	Trial	Cow group	Treatment	Av. titratable acidity				Increase
				Fresh	4 hr.	6 hr.	24 hr.	
2	1	A	Currently receiving aureomycin	0.17	0.208	0.306	0.84	0.67
		B	Previously receiving aureomycin	0.16	0.24	0.74	0.83	0.67
		C	Never received aureomycin	0.137	0.235	0.341	0.76	0.62
	2	A	Currently receiving aureomycin	0.173	0.486	0.77	0.87	0.697
		B	Previously receiving aureomycin	0.178	0.487	0.725	0.81	0.642
		C	Never received aureomycin	0.182	0.382	0.805	0.945	0.763
3	3	A	Currently receiving aureomycin	0.172	0.20	——	0.79	0.619
		B	Previously receiving aureomycin	0.20	0.218	——	0.80	0.60
		C	Never received aureomycin	0.165	0.22	——	0.83	0.665
	4	A	Currently receiving aureomycin	0.191	0.30	0.395	0.722	0.531
		B	Previously receiving aureomycin	0.188	0.34	0.413	0.725	0.537
		C	Never received aureomycin	0.19	0.306	0.391	0.738	0.548
Average			Currently receiving aureomycin					0.626
			Previously receiving aureomycin					0.610
			Never received aureomycin					0.649

Aureomycin content of milk. Aureomycin was not detected in the milk from cows previously fed aureomycin or those currently receiving the antibiotic.

DISCUSSION

The examinations for bacterial development in the raw milk samples involved only total numbers, with no consideration given to possible selective effects on different bacterial types. However, examination of samples for rates and types of defects (data not shown) that occurred on holding showed the same general quality changes in each group. Presumably, if there was any selective effect on bacterial flora, it was not great enough to influence the types of defects or rates of their development. The differences in plate counts that might suggest an effect due to feeding aureomycin generally are within the usual range of variation that arises from normal differences in flora developing in milk held at room temperature. The differences in counts are of questionable significance in milk quality control and do not justify the suggestion that aureomycin was eliminated in the milk.

TABLE 3

Effect of feeding cows aureomycin on acid development of milk during cheese making and on the score of the cheese

Trial	Cow group	Treatment	Titratable acidity		Score (3 mo.)	
			Milk	Cheese at milling	Flavor	Body and texture
1	C	Never received aureomycin	0.16	0.41	39.0	27.5
	A	Currently receiving aureomycin	0.15	0.35	38.5	29.5
2	C	Never received aureomycin	0.17	0.45	38.5	29.5
	A	Currently receiving aureomycin	0.17	0.44	40.0	28.0
3	C	Never received aureomycin	0.18	0.44	39.5	28.0
	A	Currently receiving aureomycin	0.18	0.50	39.0	29.0
4	C	Never received aureomycin	0.20	0.39	38.5	28.0
	A	Currently receiving aureomycin	0.19	0.47	38.0	27.5
Average	C	Never received aureomycin	0.177	0.42	38.9	28.25
	A	Currently receiving aureomycin	0.172	0.44	38.9	28.50

Apparently, feeding aureomycin to cows did not have any effect on amount of titratable acidity developed in the starter-inoculated milk from these cows. Neither the rate nor the final amount of acid was significantly different for the three groups. It was possible to make normal Cheddar cheese from the milk produced by the cows fed the antibiotic. The behavior of the milk during the cheese making process was normal, and the cheeses made from the two types of milk were approximately equal in quality.

The fact that no detectable amount of aureomycin was found in the milk samples previously submitted for analyses supports the results obtained.

SUMMARY AND CONCLUSION

The milk from 20 cows, in three groups, was used to determine the effect of feeding aureomycin on *(a)* bacterial development in the milk, *(b)* amount of acid developed in starter-inoculated milk, and *(c)* cheese manufacture and quality. The rate of aureomycin feeding was equivalent to an average of 390 mg. per cow daily.

The data show that there were no significant differences in total plate counts on the milk or in the amount of acid developed in the milk inoculated with starter from the three lots of cows. Cheddar cheese was made from milk produced by the cows fed the aureomycin and from milk produced by cows that had received no aureomycin. The cheeses made from milk of both groups of cows were about equal in quality, and there was no marked difference in the rate of acid development or the amount of acid produced in the cheese. No detectable amount of aureomycin was found in the milk from cows previously fed aureomycin and those currently receiving the antibiotic.

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REFERENCES

(1) BARTLEY, E. E., FOUNTAINE, F. C., AND ATKESON, F. W. Antibiotics in Dairy Cattle Nutrition. II. Effects of Feeding an Aureomycin Product (Aurofac 2A) to Lactating Cows. *J. Dairy Sci.*, **36**: 402. 1953.

(2) BRADFIELD, A., RESI, L. A., AND JOHNSTONE, D. B. The Presence of Aureomycin in Milk and Its Effect on Cheese Making and Starter Activity. *J. Dairy Sci.*, **35**: 51. 1952.

(3) HAQ, M. O., RUSOFF, L. L., AND GELPI, A. J., JR. Antibiotic Feed and Vitamin B_{12} Supplements for Lactating Dairy Cows. *Science*, **115**: 215. 1952.

(4) LOOSLI, J. K., AND WARNER, R. G. Antibiotics for Dairy Animals. Farm Research. N. Y. State Agr. Expt. Sta., *Quart. Bull.* 18, **3**: 3. 1952.

(5) OLSON, J. C., JR., WILLOUGHBY, D. S., THOMAS, E. L., AND MORRIS, H. A. Observations on the Keeping Quality of Pasteurized Milk with and without Added Aureomycin, which Was Obtained from Various Sources and Stored at 45° F. *J. Dairy Sci.*, **35**: 485. 1952.

(6) RUSOFF, L. L., AND HAQ, M. O. Studies on Aureomycin and Vitamin B_{12} Supplements for Dairy Cows. II. Effect on Production, Composition, and Vitamin B_{12} Content of the Milk. *J. Dairy Sci.*, **37**: 677. 1954.

DILUTERS FOR BOVINE SEMEN.[1] VI.

THE EFFECT OF CYSTEINE HYDROCHLORIDE ON THE LIVABILITY OF BULL SPERMATOZOA IN UNHEATED SKIMMILK

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Unheated fresh skimmilk is toxic to bull spermatozoa when used as a diluter *(8)*. The nature of the toxic factor has been of much interest recently, both in basic studies of semen metabolism and from the practical standpoint of developing an improved diluter for bull semen. The toxic factor in unheated milk, as originally defined by Thacker *et al. (9)*, was shown by them to be inactivated by heat at 92° C. though unaffected by pasteurization, nondialyzable, and present in the serum protein fraction of milk. Recent time-temperature studies conducted in this laboratory have shown that the toxic factor is inactivated when the milk is heated momentarily at about 80° C. *(6)*.

Jones and Simms *(3)*, in 1930, reported work which showed the presence of an antistreptococcal factor in milk known as lactenin. Similarity between the properties of the spermicidal factor in milk and the properties of lactenin *(3, 10, 11)* led to the hypothesis that lactenin was the spermicidal factor. Recent research by Flipse *et al. (1)* has confirmed this supposition.

Wilson and Rosenblum *(10, 11)*, in an attempt to further characterize the nature of lactenin, reported that lactenin is irreversibly inactivated by the addition of sulfhydryl compounds. Since many workers have shown that sulfhydryl groups are activated from β-lactoglobulin when milk is heated above pasteurization temperatures *(2, 4, 12)*, it was reasoned that the beneficial effect of heating milk for use as a diluter might be due to the inactivation of lactenin by sulfhydryl groups activated from β-lactoglobulin. If this postulation is correct, it should be possible to add sulfhydryl compounds to unheated skimmilk, thereby accomplishing chemically the same change brought about by heating, viz., the inactivation of lactenin, the major toxic factor in unheated skimmilk.

This paper reports results of attempts to chemically detoxify unheated skimmilk with sulfhydryl compounds.

EXPERIMENTAL PROCEDURE AND RESULTS

The milk used in all trials was fresh pasteurized skimmilk obtained from the University creamery. Semen samples were diluted to a concentration of 15 million motile spermatozoa per milliliter of diluter. Streptomycin sulfate was added in all trials at a level of 1,000γ per milliliter of diluted semen. All semen used was of high quality and was diluted within 2 hours after collection.

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The heated milk controls were prepared by placing 100 ml. of skimmilk in an Erlenmeyer flask and heating at 92° C. for 10 minutes in a water bath. The flasks were then cooled in running tap water. The diluters for the chemical treatments were prepared by weighing the particular chemical to be used, dissolving it in 2.9% sodium citrate (dihydrate) solution, and diluting the required amount of that solution to 100 ml. with unheated skimmilk. All diluters were prepared in the evening, and semen was added the following morning. After dilution, samples were slowly cooled to 4° C. and stored at that temperature. Motility estimations were made at 1, 2, 3, 4, 6, 8, 10, and 12 days after dilution by means of a microscope equipped with a thermostage.

In preliminary trials cysteine HCl was added to unheated skimmilk at varying levels. Since satisfactory livability was obtained in some cases, trials were conducted to determine the optimum level of cysteine HCl. The amount of cysteine HCl was varied from none to 4.0 mg. per milliliter of diluter. The results of these trials are presented in Table 1. Analysis of variance *(7)* showed

TABLE 1

Effect of varying levels of cysteine hydrochloride on the livability of spermatozoa in unheated skimmilk (Mean % motility of 6 ejaculates)

Levels of cysteine HCl	Days of storage at 4° C.							
	1	2	3	4	6	8	10	12
(mg/ml)								
0.00	0	0						
0.25	60	55	25	20	8	8	1	0
0.50	58	58	53	48	30	25	11	10
1.00	59	56	54	48	33	32	20	10
2.00	51	51	50	33	28	27	13	10
4.00	48	15	7	3	1	0	0	

that spermatozoan livability obtained at 0.5, 1.0, and 2.0 mg. per milliliter was highly significantly better than livability at either the higher or lower levels tested. Since 1.0 mg. per milliliter appeared to maintain livability slightly better than either 0.5 or 2.0 mg. per milliliter, this level was used in all subsequent trials.

Unheated skimmilk, heated skimmilk, and unheated skimmilk with added cysteine HCl were compared next, using 20 ejaculates of high quality semen. The results of this series of trials are shown in Table 2. No motile spermatozoa were observed in unheated skimmilk at the end of 1 day of storage. Livability in heated milk and in unheated milk containing 1.0 mg. per milliliter of added cysteine HCl was satisfactory. The cysteine-treated milk showed slightly better livability than the heated milk, and the difference approached significance at the 5% level of probability.

To determine whether the beneficial effect of added cysteine HCl could be obtained with sulfur-containing compounds in general or only with those containing reactive sulfhydryl groups, a livability trial was conducted in which equivalent concentrations of methionine and cysteine HCl were compared in

TABLE 2

Effect of unheated milk, milk heated at 92° C. for 10 minutes, and unheated milk containing 1 mg/ml of added cysteine hydrochloride on spermatozoan livability (Mean % motility of 20 ejaculates)

Treatment	Days of storage at 4° C.							
	1	2	3	4	6	8	10	12
Unheated	0	0						
Heated	56	53	51	48	41	20	11	4
Unheated plus cysteine HCl	57	56	54	52	44	25	14	7

unheated skimmilk. In methionine-treated milk, all spermatozoa were immotile after 1 day of storage, whereas satisfactory livability was obtained with cysteine-treated milk. Further trials conducted with glutathione, in concentrations calculated to release the same number of sulfhydryl groups as 1.0 mg. per milliliter of cysteine HCl, resulted in livability equal to that in cysteine-treated milk.

The question next considered was the mode of action of the sulfhydryl compounds: Do they have a direct effect on the spermatozoa, or is the effect exerted on the nondialyzable fraction of the milk, as presumed by the postulate? In an approach to this problem, protein-free milk serum, prepared by exhaustive dialysis, was substituted for skimmilk as a diluter. Results of this trial are shown in Table 3. No beneficial effect was found when cysteine HCl was added to protein-free milk serum. The difference between treatments was not statistically significant when tested by analysis of variance.

TABLE 3

Effect of cysteine hydrochloride on the livability of spermatozoa in unheated protein free milk serum (Mean % motility of 5 ejaculates)

Treatment	Days of storage at 4° C.							
	1	2	3	4	6	8	10	12
Prot. free milk serum	42	38	34	24	22	10	6	6
P.F.M.S. + 0.5 mg. cys/ml	42	38	34	28	18	12	8	4
P.F.M.S. + 1.0 mg. cys/ml	40	28	20	14	12	8	4	2

DISCUSSION

These data show that the addition of cysteine HCl to unheated skimmilk results in a semen diluent which maintains the livability of bull spermatozoa stored at 4° C. slightly better than does skimmilk heated at 92° C. for 10 minutes. The heat denaturation of certain fractions of milk serum proteins, particularly euglobulin and pseudoglobulin, has been shown to be detrimental to spermatozoan livability *(9)*. Since euglobulin and pseudoglobulin are not denatured when cysteine HCl is added, this might account for the slight improvement in livability in cysteine-treated milk as compared with heated milk.

It appears that the beneficial effect of cysteine is due to the sulfhydryl groups and not to the sulfur atoms alone, since methionine, which does not release reactive sulfhydryl groups, does not detoxify unheated skimmilk; cysteine HCl and glutathione, which release reactive sulfhydryl groups, do detoxify unheated skimmilk.

Trials with protein-free milk serum indicate rather conclusively that the beneficial effect of added cysteine HCl is exerted on the nondialyzable fraction of the milk, since no beneficial effect was found when cysteine HCl was added to protein-free milk serum.

It has been concluded, therefore, that the postulate is essentially correct: Lactenin, the major spermicidal factor in unheated skimmilk, may be rendered nontoxic by sulfhydryl groups activated from β-lactoglobulin by heat treatment of the milk or by added sulfhydryl groups in the form of sulfhydryl compounds. Further evidence supporting such a role for sulfhydryl compounds is found in work by MacLeod *(5)*, from which he concluded that the metabolism and motility of human spermatozoa are inhibited by substances which have an affinity for sulfhydryl groups and that this inhibition may be prevented and in part reversed by the addition of sulfhydryl compounds to the spermatozoa-inhibitor complex.

SUMMARY

The addition of 1 mg. of cysteine HCl per milliliter of unheated skimmilk resulted in a semen diluent which maintained the livability of bull spermatozoa stored at 4° C. equally as well as did skimmilk heated at 92° C. for 10 minutes. Cysteine HCl levels of 0.5 and 2.0 mg. per milliliter were almost as effective in supporting livability as was 1.0 mg. per milliliter; 0.25 and 4.0 mg. per milliliter were definitely inferior to the optimum level. Glutathione also was shown to be effective in supporting spermatozoan livability in unheated skimmilk, but methionine was found to be ineffective, indicating that the beneficial effect was due to the sulfhydryl groups.

When cysteine HCl was added to protein-free milk serum for use as a diluter, no improvement in spermatozoan livability was obtained, indicating that the sulfhydryl compound exerted its effect by acting on the nondialyzable portion of the unheated skimmilk rather than by acting directly on the spermatozoa.

REFERENCES

(1) Flipse, R. J., Patton, Stuart, and Almquist, J. O. Diluters for Bovine Semen. III. Effect of Lactenin and of Lactoperoxidase upon Spermatozoan Livability. *J. Dairy Sci.*, **37**: 1205. 1954.

(2) Hutton, J. T., and Patton, S. The Origin of Sulfhydryl Groups in Milk Protein and Their Contributions to "Cooked Flavor." *J. Dairy Sci.*, **35**: 699. 1952.

(3) Jones, F. S., and Simms, H. S. The Bacterial Growth Inhibitor (Lactenin) of Milk. I. The Preparation in Concentrated Form. *J. Exptl. Med.*, **51**: 327. 1930.

(4) Larsen, R. A., Jenness, R., and Geddes, W. F. Effect of Heat Treatment on the Sulfhydryl Groups of Milk Serum Proteins. *Cereal Chem.*, **26**: 287. 1949.

(5) MacLeod, J. Sulfhydryl Groups in Relation to the Metabolism and Motility of Human Spermatozoa. *J. Gen. Physiol.*, **34**: 705. 1951.

(6) Saacke, R. G., and Almquist, J. O. Unpublished Data. Pa. Agr. Expt. Station. 1954.

(7) Snedecor, G. W. *Statistical Methods.* 4th ed. The Iowa State College Press, Ames. 1946.

(8) Thacker, D. L., and Almquist, J. O. Diluters for Bovine Semen. I. Fertility and Motility of Bovine Spermatozoa in Boiled Milk. *J. Dairy Sci.*, **36**: 173. 1953.

(9) THACKER, D. L., FLIPSE, R. J., AND ALMQUIST, J. O. Diluters for Bovine Semen. II. Effect of Milk Proteins upon Spermatozoan Livability. *J. Dairy Sci.*, **37**: 220. 1954.

(10) WILSON, A. T., AND ROSENBLUM, H. The Antistreptococcal Property of Milk. I. Some Characteristics of the Activity of Lactenin in Vitro. The Effect of Lactenin on Hemolytic Streptococci of the Several Serological Groups. *J. Exptl. Med.*, **95**: 25. 1952.

(11) WILSON, A. T., AND ROSENBLUM, H. The Antistreptococcal Property of Milk. II. The Effects of Anaerobiosis, Reducing Agents, Thiamine, and Other Chemicals on Lactenin Action. *J. Exptl. Med.*, **95**: 39. 1952.

(12) ZWEIG, G., AND BLOCK, R. J. The Effect of Heat Treatment on the Sulfhydryl Groups in Skimmilk and Nonfat Dry Milk. *J. Dairy Sci.*, **36**: 427. 1953.

THE VALUE OF CORN SILAGE AND RECOMBINED CORN SILAGE IN RESPECT TO MILK PRODUCTION[1]

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In a previous publication, Huffman and Duncan *(1)* showed that corn silage was superior to hay for milk production on a total digestible nutrient (TDN) basis. The superiority of the TDN in the corn silage was attributed to the presence of an unidentified lactation factor(s) in the corn which is needed to balance the hay for efficient milk production *(2, 3, 4)*. The cows were maintained on an all-hay ration until they dropped markedly in milk production and then part of the hay was replaced with either grain or corn silage on an equal TDN basis. This depletion method makes it possible to test for the presence of the unidentified milk-stimulating factor(s) found in grains and some hays.

The results of the work with corn silage *(1)* suggested the possibility that the corn in corn silage may be just as valuable as the corn grain harvested from the field, stored in bins, ground into a meal, and then fed in the manger. The purpose of this paper was to compare the value of the corn in corn silage prepared in the usual way with corn and cob meal fed in conjunction with grainless corn silage. The term "grainless corn silage" is construed to mean the silage made from the stalks and leaves after the ears had been removed. The ears that were removed were dried with supplemental heat and then ground to give corn and cob meal. The term "recombined corn silage" is construed to mean that a proportionate amount of the corn and cob meal was added to the grainless corn silage at the time of feeding.

EXPERIMENTAL

Just before the corn was harvested for silage, random samples of the green corn plant were collected from the field. The weights per acre of the green corn, corn stalks, and ears were calculated. All of the samples were dried. From the dry weights, the amount of corn silage required to yield 1 lb. of U. S. No. 2 corn and the yield per acre of corn and cob meal were calculated. King's Cross and Ohio M15 varieties were grown in 1946 and 1948, respectively, and used in this experiment.

The corn crop was unfavorable in 1946 because of drought. The yield of green corn was 5.25 tons per acre, which was equivalent to 24.9 bu. of U. S. No. 2 shelled corn. Each 7.5 lb. of green corn contained 1 lb. of U. S. No. 2 shelled corn.

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In 1948, 12.85 tons of green corn and 58.8 bu. of U. S. No. 2 shelled corn per acre were obtained. Each 7.8 lb. of the green corn contained 1 lb. of U. S. No. 2 corn.

Alternate strips of green corn were placed in the silo in the early dent stage. About 5% of the stalks of the 1946 crop were without ears. The corn was cut in 0.5-in. lengths for silage. The remaining strips of green corn were used for the grainless corn silage. In 1946, part of the ears were husked and dried in a corn drier and part were snapped and dried with the husks. All of the ears were husked and dried in 1948 when the grainless corn silage was made.

The chemical composition, coefficients of digestibility, digestible protein, and the TDN content of the various feedstuffs used in the experiment are presented in Table 1. The corn silage (feed No. 2) fed in Trials 1 to 7, inclusive, was of good quality from the standpoint of appearance and aroma. The pH was 4.1.

TABLE 1

Description of the feeds used in the experiment

Feed No.	Used in trials	Feedstuff	Moisture	Ash	Protein	Ether ext.	Crude fiber	NFE	Dig. prot.	TDN
			(%)	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
1	1-7	Clover hay	12.1[a]	5.7	10.7	1.56	29.4	40.5	5.03	46.8
					47	51	52	61		
2	1-7	Corn silage	67.8	1.7	3.2	0.99	6.5	19.8	1.67	22.2
					52	70	66	74		
3	1-7	Grainless corn silage	69.6	2.3	2.9	1.01	8.3	15.9	1.23	17.9
					42	59	63	64		
4	1-7	Corn and cob meal	13.5	1.5	9.0	2.19	7.4	66.4	5.58	69.7
					62[b]	70	57	85		
5	8-14	Alfalfa, 2nd cut.	10.6	5.9	14.2	2.32	28.6	38.4	10.22	51.6
					72[c]	34	43	71		
6	8-14	Corn silage	70.3	1.2	2.8	2.18	5.9	17.6	1.47	21.2
					53[c]	74	66	69		
7	8-14	Grainless corn silage	77.0	1.5	1.4	0.78	7.4	11.9	0.60	13.9
					42	59	63	64		
8	8-14	Corn and cob meal	13.6	3.3	8.8	3.02	7.3	64.0	5.46	68.7
					62[b]	70	57	85		

[a] The first line for each feed represents the chemical composition and the second line represents the coefficients of digestibility. All coefficients were obtained experimentally, except the lines marked with footnotes [b] and [c].

[b] Coefficients calculated from Morrison's *(7)* coefficients for corn and corn cobs.

[c] Morrison's coefficients.

Feed No. 3 was the grainless corn silage fed in Trials 1 to 7. The pH was 3.96. The basal hay used in these trials was U. S. No. 3 clover. In Trials 8 to 14, inclusive, the 1948 crops were fed. Feeds No. 6 (corn silage) and No. 7 (grainless corn silage) had pH values of 3.82 and 3.73, respectively. Both silages were good quality. The basal hay used in these trials was U. S. No. 3 alfalfa, extra leafy.

The coefficients of digestibility were determined on feeds No. 1, 2, and 3. Two cows were used to determine the coefficients for clover hay (No. 1) and four cows each were used for the corn silage (No. 2) and grainless corn silage (No. 3). The coefficients used for the corn and cob meal (feeds No. 4 and 8) were calculated by using Morrison's *(7)* coefficients for corn grain and corn cobs. Morrison's coefficients were also used for the alfalfa hay and corn silage (feeds No. 5

and 6). The same coefficients were used for feed No. 7 as were determined for No. 3.

The basal ration consisted of hay and regular corn silage. During the experimental periods the corn silage was replaced with recombined corn silage (grainless corn silage and corn and cob meal in amounts approximating the composition of the corn silage).

Eleven Holstein and two Brown Swiss cows were used in 14 trials to evaluate the recombined corn silage. The milk was handled as reported previously *(1)*, and the cows were weighed every third day. The TDN requirements suggested by Loosli *et al. (6)* were used. The initial days in lactation at the start of the experiment varied from 45 in Trial 7 to 236 days in Trial 10.

The relative value of corn silage and recombined corn silage was determined in a reversal type of experiment. In Trials 1 to 7, inclusive, corn silage was fed first for a 9- to 18-day period, then recombined corn silage was fed for an 18-day period, which was followed by the regular corn silage. In Trials 8, 9, 12, and 13 the cows were changed twice from the basal to the experimental ration. In Trials 10, 11, and 14 the cows were removed from the experiment following the second period on recombined silage.

RESULTS AND DISCUSSION

The coefficients of digestibility determined for the 1946 corn silage were in good agreement with those reported by Morrison *(7)* for corn silage, all analyses. The coefficients obtained for the grainless corn silage for protein, ether extract, crude fiber, and NFE were 42, 59, 63, and 64, respectively. These values are in good agreement with those reported by Livesay *et al. (5)*, who determined 38, 59, 67, and 56, respectively, for the above constituents in grainless corn silage.

The comparative results obtained for the corn silage and recombined corn silage are presented in Tables 2 and 3. The data in Table 2 show the average daily production of FCM and the TDN intake when the cows received the two types of corn silage. In Trials 1 to 7, inclusive, the data show that the combination of 22.5 lb. of grainless corn silage and 7.5 lb. of corn and cob meal supplied practically the same amount of TDN as 50 lb. of corn silage. In all of these trials milk production declined with the advance in lactation regardless of the type of silage fed. In Table 3 the milk production obtained in periods *a* and *c* is compared with that obtained in period *b* and shows that the cows averaged 22.4 lb. of FCM per day on corn silage and 22.5 lb. per day on the recombined corn silage.

In Trials 8 to 14, inclusive, about 50 lb. of corn silage were replaced with about 34 lb. of grainless corn silage and 9 lb. of corn and cob meal. In Trials 9, 11, 12, and 14 the cows increased in the production of FCM in the first trial when changed to recombined corn silage. There was no change in Trial 13, but the cows decreased in Trials 8 and 10. In the second change from corn silage to recombined corn silage there was a decline in FCM in Trials 8 to 12, inclusive, and a slight increase in Trials 13 and 14. As shown in Trials 1 to 7, inclusive, in Table 3, the cows fed corn silage and recombined corn silage averaged 22.4

TABLE 2

Milk and butterfat production obtained when recombined corn silage replaced regular corn silage

Trial No.	Period	In milk	In period	FCM	Test	Hay	Corn silage	Grainless corn silage	Corn and cob meal	TDN
		(days)	*(days)*	*(lb.)*	*(%)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*
					Clover hay and 1946 silages					
1	a	95	12	16.6	3.2	15.0	45.5	—	—	17.1
	b	107	18	15.1	3.2	15.0	—	32.5	7.5	18.1
	c	125	18	13.5	3.4	15.0	34.6	—	—	14.7
2	a	216	12	26.8	3.2	13.8	50.0	—	—	17.6
	b	228	18	23.8	3.2	14.7	—	32.5	7.5	17.9
	c	246	18	17.0	3.6	14.4	50.0	—	—	17.8
3	a	176	12	24.1	3.7	15.0	45.0	—	—	17.0
	b	188	18	23.0	3.7	13.8	—	32.5	7.5	17.5
	c	206	18	21.2	4.3	13.6	50.0	—	—	17.5
4	a	175	12	19.4	3.9	15.0	44.9	—	—	17.0
	b	187	18	18.0	3.7	15.0	—	29.8	7.5	17.6
	c	205	18	17.3	4.0	15.0	35.1	—	—	14.8
5	a	105	18	24.5	3.3	14.0	50.0	—	—	17.6
	b	123	18	23.8	3.3	14.9	—	32.5	7.5	18.0
	c	141	27	24.0	3.5	14.5	50.0	—	—	17.9
6	a	168	18	24.2	3.7	13.9	50.0	—	—	17.6
	b	186	18	21.9	3.8	14.3	—	32.5	7.5	17.7
	c	204	18	19.6	4.0	14.3	50.0	—	—	17.8
7	a	45	9	36.9	3.8	15.0	40.4	—	—	16.0
	b	54	18	31.8	3.5	14.8	—	32.5	7.5	18.0
	c	72	18	28.7	3.3	14.1	49.4	—	—	17.6
					Second cutting alfalfa hay and 1948 silages					
8	a	66	12	36.2	3.4	15.0	50.0	—	—	18.3
	b	78	12	32.6	3.0	15.0	—	34.0	9.0	18.7
	c	90	21	34.1	3.6	14.9	50.0	—	—	18.3
	d	111	18	31.5	3.1	14.9	—	34.0	9.0	18.6
	e	129	12	30.6	3.3	14.9	49.9	—	—	18.3
9	a	132	12	26.3	3.9	15.0	50.0	—	—	18.3
	b	144	12	28.3	3.9	15.0	—	34.0	9.0	18.7
	c	156	21	27.3	4.1	15.0	50.0	—	—	18.3
	d	177	18	26.7	3.8	14.6	—	33.6	9.0	18.4
	e	195	15	26.4	4.0	14.9	49.9	—	—	18.3
10	a	236	12	23.4	3.4	15.0	49.6	—	—	18.3
	b	248	12	22.7	3.3	15.0	—	33.1	9.0	18.5
	c	260	27	21.7	3.6	14.7	50.0	—	—	18.2
	d	287	12	17.9	3.6	14.6	49.4	—	—	18.0
	e	299	15	15.6	3.6	15.9	—	31.7	9.0	18.3
11	a	154	12	20.9	4.0	15.0	50.0	—	—	18.3
	b	166	12	21.7	3.7	15.0	—	34.0	9.0	18.7
	c	178	27	21.4	4.0	15.0	50.0	—	—	18.3
	d	205	12	18.8	3.8	14.3	49.6	—	—	17.9
	e	217	15	18.3	3.5	14.7	—	32.7	9.0	18.3
12	a	210	12	23.7	3.8	15.0	50.0	—	—	18.3
	b	222	12	24.1	3.8	15.0	—	34.0	9.0	18.7
	c	234	21	24.0	4.0	14.9	49.7	—	—	18.2
	d	255	18	22.9	3.8	14.8	—	33.8	9.0	18.6
	e	273	12	20.3	4.0	14.9	49.7	—	—	18.2

(continued on following page)

TABLE 2 (concluded)

Milk and butterfat production obtained when recombined corn silage replaced regular corn silage

Trial No.	Period	In milk	In period	FCM	Test	Hay	Corn silage	Grainless corn silage	Corn and cob meal	TDN
		(days)	*(days)*	*(lb.)*	*(%)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*
13	a	147	12	21.3	3.4	15.0	50.0	—	—	18.3
	b	159	12	21.3	3.3	15.0	—	34.0	9.0	18.7
	c	171	21	19.5	3.6	15.0	50.0	—	—	18.3
	d	192	18	20.1	3.7	15.0	—	34.0	9.0	18.7
	e	210	12	19.8	3.4	15.0	50.0	—	—	18.3
14	a	150	12	26.9	3.9	15.0	50.0	—	—	18.3
	b	162	12	27.4	3.7	15.0	—	34.0	9.0	18.7
	c	174	7	24.9	3.9	15.0	50.0	—	—	18.3
	d	181	12	24.3	3.9	15.0	49.0	—	—	18.1
	e	193	12	24.5	3.8	15.0	—	33.6	9.0	18.6

and 22.5 lb. of FCM and 24.1 lb. on both the basal and experimental rations in Trials 8 to 14. These results indicate that the grain in corn silage is just as effective in maintaining milk production as when it is fed as dry corn and cob meal. The results confirm previous findings reported by Huffman and Duncan *(1)* that the replacement of part of the TDN in an all-hay ration with an equal amount of TDN in the form of corn silage increased milk production and also confirm the suggestion that when grain is fed in rations containing corn silage an allowance should be made for the corn grain present in the silage.

There was a tendency for the percentage of butterfat to decline during the periods when recombined corn silage was fed, but no significant differences in body weight were noted when the two types of corn silage were fed.

The digestible protein and TDN requirements were calculated by using the allowances recommended by the National Research Council *(6)*. In Trials 3, 5, 6, 7, 2c, 4a, and 4c the cows received less of digestible protein than was required. The requirement data were deleted from Table 2. Table 3 shows that the mean amounts of digestible protein ingested on the two types of silage were very close. The TDN intakes, however, were 0.8 lb. higher in Trials 1 to 7, inclusive, and 0.4 lb. higher in Trials 8 to 14, inclusive, when the cows received recombined corn silage. Since the cows produced the same amount of FCM on the corn silage ration as they did on the recombined corn silage ration, the data indicate that the corn grain in corn silage is just as productive as corn grain fed in the form of dry corn and cob meal.

SUMMARY

Corn silage and grainless corn silage were prepared in 1946 and 1948 from alternate strips in corn fields. The grainless corn silage was made by harvesting the corn stalks after the ears had been removed. The ears were dried and ground to give corn and cob meal.

The coefficients of digestibility of both silages were determined for the 1946

TABLE 3

Summary of FCM, body weights, and the digestible protein and TDN intakes during the corn silage and recombined corn silage periods

Trial No.	FCM		Body weight		Digest. protein		TDN	
	Corn[a] silage	R.C.[b] silage	Corn silage	R.C. silage	Corn silage	R.C. silage	Corn silage	R.C. silage
	(lb.)	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*
	Clover hay and 1946 silages							
1	15.0	15.1	1127	1143	1.42	1.57	15.9	18.1
2	21.9	23.8	1165	1173	1.54	1.56	17.7	17.9
3	22.6	23.0	1107	1120	1.51	1.51	17.2	17.5
4	18.3	18.0	1126	1143	1.42	1.54	15.9	17.6
5	24.2	23.8	1155	1148	1.55	1.57	17.7	18.0
6	21.9	21.9	1324	1326	1.54	1.54	17.7	17.7
7	32.8	31.8	1160	1149	1.48	1.56	16.8	18.0
Av.	22.4	22.5	1166	1172	1.49	1.55	17.0	17.8
	Second cutting alfalfa hay and 1948 silages							
8	35.1	32.6	1120	1135	2.26	2.23	18.3	18.7
	32.3	31.5	1112	1105	2.26	2.22	18.3	18.6
9	26.8	28.3	1180	1171	2.27	2.23	18.3	18.7
	26.8	26.7	1179	1194	2.26	2.19	18.3	18.4
10	22.5	22.7	1155	1159	2.25	2.22	18.2	18.5
	17.9[c]	15.6	1208	1208	2.22	2.20	18.0	18.3
11	21.1	21.7	1110	1106	2.27	2.23	18.3	18.7
	18.8[c]	18.3	1118	1123	2.19	2.19	17.9	18.3
12	23.8	24.1	1173	1172	2.26	2.23	18.2	18.7
	22.1	22.9	1200	1196	2.25	2.21	18.2	18.6
13	20.4	21.3	1399	1407	2.27	2.23	18.3	18.7
	19.6	20.1	1423	1420	2.27	2.23	18.3	18.7
14	25.9	27.4	1164	1172	2.27	2.23	18.3	18.7
	24.3[c]	24.5	1171	1184	2.25	2.23	18.1	18.6
Av.	24.1	24.1	1194	1197	2.25	2.22	18.2	18.6

[a] Average of periods *a* and *c* or *c* and *e*.
[b] R. C. = recombined corn silage-period.
[c] Single values.

crop. When recombined corn silage was fed, the amount of corn and cob meal fed was equivalent to the amount of corn in the regular corn silage. The data obtained by randomizing the corn field just prior to ensiling were used to calculate the amounts of grainless corn silage and corn and cob meal to be fed.

The two silages were compared in respect to milk production by using 13 cows in 14 trials. The average amount of FCM produced, the body weights, and the amount of digestible protein ingested during the corn silage and recombined corn silage periods were approximately the same in both cases. The data indicate that the corn grain in corn silage was of the same value for milk production as corn grain fed in the form of dry corn and cob meal.

REFERENCES

(1) Huffman, C. F., and Duncan, C. W. The Nutritive Value of Corn Silage for Milking Cows. *J. Dairy Sci.*, **37**: 957. 1954.

(2) Huffman, C. F., and Duncan, C. W. The Nutritive Value of Alfalfa Hay. III. Corn as a Supplement to an All-Alfalfa Hay Ration for Milk Production. *J. Dairy Sci.*, **32**: 465. 1949.

(3) Huffman, C. F., and Duncan, C. W. Unidentified Dietary Factors in Dairy Cattle Nutrition. I. Digestibility of Peanut Hulls and Their Use in "Ballast" Studies with Milking Cows Depleted on Hay Alone. *J. Dairy Sci.*, **35**: 30. 1952.

(4) Huffman, C. F., Duncan, C. W., and Chance, C. M. Unidentified Dietary Factors in Dairy Cattle Nutrition. II. Further Evidence of an Unidentified Factor(s) in Grain Needed to Balance Roughage for Milk Production. *J. Dairy Sci.*, **35**: 41. 1952.

(5) Livesay, F. H., Van Landingham, A. H., and Schneider, B. H. Corn Silage Studies. *Proc. Am. Soc. Animal Production*, 23rd Ann. Meeting, p. 126. 1940.

(6) Loosli, J. K., Huffman, C. F., Petersen, W. E., and Phillips, P. H. Recommended Nutrient Allowances for Domestic Animals. III. Recommended Nutrient Allowances for Dairy Cattle. *National Research Council Bull.* Washington, D. C. 1950.

(7) Morrison, F. B. *Feeds and Feeding.* 21st ed. The Morrison Publ. Co., Ithaca, New York. 1948.

STUDIES ON MILK FEVER IN DAIRY COWS. IV. PREVENTION BY SHORT-TIME, PREPARTUM FEEDING OF MASSIVE DOSES OF VITAMIN D

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Previous unsuccessful attempts to reduce milk fever incidence by feeding one to five million units of vitamin D per day for 2 to 4 weeks prepartum *(9, 10, 11)* were attributed to insufficient calcemic effect to maintain the prepartum increase observed in the blood calcium level during the critical 18-24 hour postpartum period. Based on the results of Campbell and Turner *(5)*, it was reasoned *(11)* that this may have been due, at least in part, to suppression of parathyroid activity resulting from the prolonged prepartum elevation of blood calcium. Accordingly, a series of experiments, herein reported, was conducted in which larger doses of vitamin D were fed for shorter periods of time prepartum. The aim in these experiments was to try to prevent milk fever by supplementing parathyroid activity by using a shorter prepartum period of vitamin D feeding and elevated blood calcium.

Clinically abnormal heart action in some cows fed relatively smaller amounts of vitamin D for longer periods of time had been observed *(12)*. Also, what appeared to be calcium depositions were noted in the endocardium and the intima of the aorta in one cow *(12)*. These observations led to a study in cooperation with the Departments of Veterinary Pathology and Veterinary Physiology and Pharmacology, College of Veterinary Medicine, The Ohio State University, to determine the safe limitations of vitamin D dosage, taking into consideration both daily dosage and duration of feeding. The results of these studies are being prepared for publication *(7, 13)*. Also, in order to determine the possible effects of vitamin D feeding and milk fever on parathyroid activity, a study was carried out in cooperation with the Department of Veterinary Pathology *(18)*.

EXPERIMENTAL PROCEDURE AND RESULTS

During the period 1947-1953, varying amounts of vitamin D, from 5 to 30 million U.S.P. units per day, were fed for 3 to 8 days prepartum in different years to the available Jersey cows in the herd. All cows included had at least two previous lactations, and most of them had clinical manifestations of milk fever at previous parturitions.

Two sources of vitamin D were fed: *(a)* irradiated dry yeast (types 36F and 142F, containing 36,000 and 142,000 U.S.P. units per gram, respectively) and *(b)*, viosterol (irradiated ergosterol 1,000,000 U.S.P. units per gram dissolved in corn oil). The irradiated yeast was fed by premixing one-half the daily dose with the grain at each A.M. and P.M. feeding. The grain mixture containing

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the yeast was mixed with silage when silage was available. A few cows did not begin to eat the yeast soon enough and were excluded from the experiment. The viosterol was given in gelatin capsules with a balling gun. All cows were subjected to the usual feeding and management practices employed in the herd during the dry period. The roughage for the most part was medium to good quality legume hay, meadow crop and corn silage, and pasture in season. Simple grain mixtures were fed in moderate amounts.

Some difficulty was encountered in predicting the calving date within the required range. Cows which freshened before three full days of vitamin D feeding or failed to freshen within one day after termination of vitamin D feeding were excluded from the data. Cows that calved before eight full days of vitamin D feeding were given one postpartum dose at the next feeding after parturition. Thus, only the cows which received from 3 to 8 days of vitamin D feeding were included. Data were obtained from some cows at more than one parturition after different treatments. All cows were milked out as completely as possible at the next milking after parturition.

The milk fever incidence data at parturitions after various levels of vitamin D feeding in comparison to the controls are presented in Table 1.

TABLE 1

Effect of various amounts of vitamin D fed for a few days prepartum on milk fever incidence in Jersey cows[a]

USP units of vitamin D fed daily (3-8 days prepartum)	No. of parturitions	No. with milk fever at previous parturitions	No. of milk fever cases	Per cent incidence of milk fever	Source of vitamin D fed
30 million	10	10	0	0	5 cows fed 142-F irradiated dry yeast[b] and 5 fed viosterol[c]
20 million	4	4	0	0	viosterol[c]
10 million	12	7	1	8	viosterol[c]
5 million	5	2	1	20	36-F irradiated dry yeast[d]
Controls—no vitamin D, no milk fever at previous parturitions	50	0	27	54	
Milk fever at previous parturitions	22	22	14	64	

[a] All cows had at least two previous lactations.
[b] 142,000 units per gram.
[c] 1 million units per gram, irradiated ergosterol dissolved in corn oil.
[d] 36,000 units per gram.

Before vitamin D feeding was begun, a sample of jugular blood was drawn from each cow for serum calcium *(6)*, phosphorus *(4)*, and magnesium *(3)* analysis. When possible, similar analyses were made within 12 hours before parturition, within 12 hours postpartum, at approximately 24 hours postpartum, and in some instances at 48 hours, 74 hours, and 1 week postpartum.

TABLE 2

Effect of various amounts of vitamin D fed for a few days prepartum on the blood serum Ca, P, and Mg of normally freshening Jersey cows[a]

USP units of vitamin D fed daily (3-8 days prepartum)	Blood serum constituent	Approx. 1 wk. pre-fresh. (pre-vit. D)	Within 12 hr. pre-fresh.	Within 12 hr. post-fresh.	Approx. 24 hr. post-fresh.	Approx. 48 hr. post-fresh.	Approx. 72 hr. post-fresh.	Approx. 1 wk. post-fresh.
		(mg. %)	*(mg. %)*	*(mg. %)*	*(mg. %)*	*(mg. %)*	*(mg. %)*	*(mg. %)*
30 million	Ca	11.55 (9)[b]	12.23 (8)	11.04 (10)	11.81 (9)	11.84 (8)	12.29 (5)	
	P	5.94 (5)	8.09 (6)	6.96 (6)	7.24 (6)	8.87 (6)	10.49 (4)	
	Mg	1.93 (5)	2.09 (6)	2.36 (7)	2.27 (7)	2.39 (7)	1.70 (5)	
20 million	Ca	11.79 (3)	11.83 (3)	11.50 (3)	12.70 (3)			
	P	4.83 (3)	5.90 (3)	7.68 (3)	6.91 (3)			
	Mg		2.72 (3)	2.25 (3)	2.09 (3)			
10 million	Ca	10.34 (11)	10.88 (7)	9.76 (11)	9.95 (10)			9.48 (4)
	P	4.58 (10)	6.44 (7)	4.57 (10)	4.82 (11)			5.62 (4)
	Mg	2.31 (7)	2.31 (3)	2.38 (7)	2.25 (7)			
5 million	Ca	11.44 (2)	11.84 (2)	11.89 (2)	11.95 (1)			11.32 (2)
	P	6.14 (2)	5.18 (2)	5.41 (2)	4.52 (1)			3.89 (2)
	Mg	2.40 (2)	2.62 (2)	1.92 (2)	1.12 (1)			2.14 (1)
Controls (No vitamin D)	Ca	10.32 (7)	9.90 (5)	8.72 (8)	8.62 (5)			10.31 (4)
	P	5.49 (7)	4.28 (3)	4.44 (7)	4.91 (7)			5.88 (4)
	Mg	2.14 (6)	2.19 (4)	2.65 (7)	2.69 (4)			1.70 (4)

[a] All cows had at least two previous lactations.

[b] Number of parturitions represented in the average indicated in parentheses.

The average results of the blood analyses made at normal parturitions in which various amounts of vitamin D were fed for 3 to 8 days prepartum are compared (Table 2) with normal parturitions in which the cows were not fed vitamin D. Some of the control cows had been fed vitamin D prior to previous parturitions.

Complete chemical data were not available at all parturitions, and the number of parturitions represented in the averages are indicated in parentheses in the table. Complete serum calcium and phosphorus data were available from only six parturitions in which the cows were fed at the 10-million unit level, three at the 20-million unit level, and four at the 30-million unit level. These data, along with the control data from Table 2, are shown graphically in Figure 1.

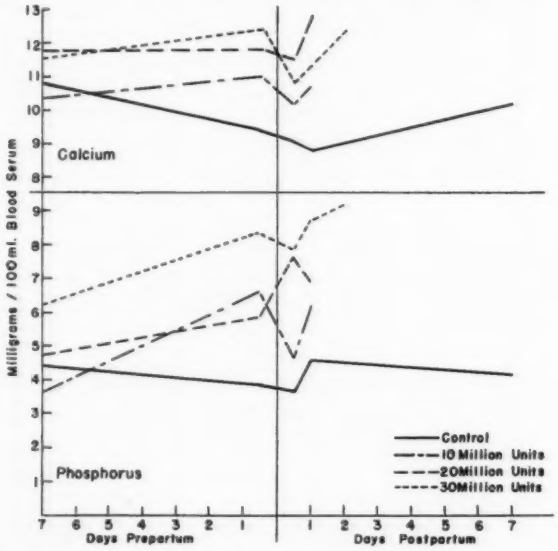

FIG. 1. The effect of various amounts of vitamin D fed for 3 to 8 days prepartum on the blood serum Ca and P levels of normally freshening Jersey cows. All had at least two previous lactations.

TABLE 3

Effect of feeding 30 million units of vitamin D daily for 7 days prepartum on the vitamin D content of colostrum and milk

No. of cows	Day postpartum sampled	Av. vitamin D/g butterfat	Av. vitamin D/qt milk[a]
		(i.u.)	*(i.u.)*
1[b]	1st	300	12,000
4	3rd-4th	93	3,720
4	6th-7th	55	2,200

[a] Estimated assuming 40 g. of butterfat per quart of milk.

[b] Two other 1st day samples assayed less than 300 units per gram, but exact amount was not determined.

Vitamin D assays were made on a limited number of colostrum and milk samples taken from vitamin D fed cows during the first week postpartum. These results are presented in Table 3.

DISCUSSION

An indication of the high incidence of milk fever in the Ohio Agricultural Experiment Station Jersey herd can be seen in the per cent incidence of the controls, each of which had at least two previous lactations (Table 1). When the parturitions of cows in this herd with previous milk fever histories (64% incidence) are separated from those with no previous history, the per cent incidence is only slightly higher than in cows with at least two previous lactations but with no previous milk fever attacks (54% incidence).

Although only five parturitions were included, the feeding of as little as 5 million units of vitamin D daily for 3 to 8 days prepartum appeared to afford some protection (Table 1). Blood data were too restricted in this group to serve as a reliable indicator of the degree of protection from this level of feeding. However, the two cows in this group which were bled, neither of which had previous milk fever histories, did maintain a relatively high blood calcium level throughout the critical postpartum period (Table 2).

The further lowering of milk fever incidence at the 10 million units per day level of vitamin D feeding and the complete protection to date resulting from the 20 and 30 million unit levels (Table 1) were accompanied by the maintenance of blood calcium and phosphorus at levels higher than the controls, during the critical postpartum period (Table 2 and Figure 1).

The relatively high blood calcium level maintained during the critical postpartum period is believed to be the cause of, or at least an indicator of, the protection against milk fever. However, the mode of action of vitamin D in eliciting the increased blood calcium, much of which was apparently due to ionic calcium *(13)*, is not well understood.

The extremely low parathyroid activity, the increased gland size, and the histological changes in the parathyroid glands of cattle fed massive doses of vitamin D compared to the controls *(18)* indicated that the observed increase in blood calcium was not due to parathyroid stimulation but may have been caused by increased intestinal absorption, lowered intestinal excretion, or some direct effect on calcium mobilization from skeletal reserves. Thus, the calcemic (blood calcium raising) effect of massive doses of vitamin D seems to be the result of a parathyroid replacement action which provides for the maintenance of higher than normal blood calcium levels during the critical postpartum period despite the hypo-parathyroid function resulting from the vitamin D feeding.

These observations are not in support of the hypothesis of Taylor *et al. (15, 16)* working with dogs, in which the calcemic action of vitamin D was attributed to its stimulating effect directly on parathyroid tissue. Further, Taylor *et al. (17)* found that dogs made tolerant to repeated doses of parathyroid hormone were resistant to the toxic effects of large doses of vitamin D, even though a high

level of blood calcium persisted for several weeks. This apparent lack of agreement may be associated with the recognized resistance of the bovine to the calcemic action of vitamin D as compared to the dog and some other animals.

The marked increase in serum phosphorus at these high levels of vitamin D feeding (Table 2 and Figure 1), although apparently not directly concerned with milk fever prevention, may be indicative of the parathyroid depressing effects of vitamin D. Parathyroid gland removal has been shown by Talmage *et al. (14)* to cause a rise in serum phosphorus, which was restored to normal by parathormone injection. Other possible causes of the increased phosphorus level are mobilization from the skeletal reserves or some alteration in intestinal absorption or excretion.

Additional work on the relationships of blood calcium and phosphorus, vitamin D, and parathyroid function in connection with milk fever has been reviewed in more detail *(8)*. Boda and Cole *(1)* have reported recently that milk fever can be controlled by feeding a low-calcium, high-phosphorus diet. This effect is presumably due to prepartum parathyroid stimulation.

The results of toxicity studies *(7, 13)* in which 30 million units of vitamin D were fed for various periods showed no serious pathologic effects when administration was limited to 10 days or less. However, prolonged feeding of the 30 million units of vitamin D for 21 to 30 days resulted in definite signs of toxicity. On this basis it would seem wise to limit the feeding of vitamin D to 7 days or less in order to avoid any possible harmful effects and to provide a margin of safety.

The milk fever incidence data in Table 1 show the effectiveness of various levels of vitamin D feeding for 3 to 8 days prepartum. Both sources of vitamin D, irradiated dry yeast or viosterol, appeared to be equally effective. Because of the small numbers fed the 5 and 20 million unit levels, it cannot be said with certainty what the minimum effective dosage would be. However, some degree of protection against milk fever appeared to result from all four levels of vitamin D feeding. Thirty-million units of vitamin D per day fed for 3 to 8 days prepartum has given complete protection to date.

As suggested earlier, the prediction of the date of parturition within these relatively narrow limits poses a problem which cannot be completely overcome without more accurate means for determining the calving date in advance. The known factors which influence length of gestation have recently been reviewed by Brakel *et al. (2)*.

As indicated in Table 3, the vitamin D content of the colostrum and milk declines rapidly during the first few days. Vitamin D fortified milk normally contains at least 400 units per quart, and much higher therapeutic doses are routinely given than would reasonably be expected to be consumed from drinking the milk of vitamin D treated cows for a short time. These levels of vitamin D are therefore not considered to be a health hazard either to humans or to calves.

On a practical basis, this preventive treatment should be used on cows with previous history of milk fever or on cows with at least two previous lactations in herds where a high incidence of milk fever had been experienced.

SUMMARY AND CONCLUSIONS

Various levels of vitamin D — 5, 10, 20, and 30 million units per day in the form of irradiated dry yeast and viosterol (irradiated ergosterol in oil) — were fed to mature Jersey cows for 3 to 8 days prepartum. The maintenance of a high blood serum level of calcium and phosphorus during the critical postpartum period was used along with clinical observations as criteria for determining the effectiveness of various levels of vitamin D feeding in preventing milk fever. The physiological basis for these blood changes is discussed.

Some protection was attributed to the two lower levels of vitamin D feeding, and complete protection to date has resulted from the higher dosages. Thus, the feeding of 30 million units of vitamin D per day for at least 3 days and preferably not more than 7 days prepartum and 1 day postpartum offers a simple, safe, and effective method for milk fever prevention. The minimum effective dosage of vitamin D for milk fever prevention has not been accurately determined.

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REFERENCES

(1) Boda, J. M., and Cole, H. H. The Influence of Dietary Calcium and Phosphorus on the Incidence of Milk Fever in Dairy Cows. *J. Dairy Sci.*, **37**: 360. 1954.

(2) Brakel, W. J., Rife, D. C., and Salisbury, S. M. Factors Associated with the Duration of Gestation in Dairy Cattle. *J. Dairy Sci.*, **35**: 179. 1952.

(3) Briggs, A. P. A Colorimetric Method for the Determination of a Small Amount of Magnesium. *J. Biol. Chem.*, **52**: 349. 1922.

(4) Briggs, A. P. A Modification of the Bell Doisy Phosphate Method. *J. Biol. Chem.*, **53**: 13. 1922.

(5) Campbell, I. L., and Turner, C. W. The Relationship of the Endocrine System to the Regulation of Calcium Metabolism. Mo. Agr. Expt. Sta., *Research Bull.* 352. 1943.

(6) Clark, E. P., and Collip, J. B. A Study of the Tisdall Method for the Determination of Blood Serum Calcium with Suggested Modifications. *J. Biol. Chem.*, **63**: 461. 1925.

(7) Cole, C. R., Chamberlain, D. M., and Hibbs, J. W. (In preparation for publication.)

(8) Hibbs, J. W. Milk Fever (Parturient Paresis) in Dairy Cows—A Review. *J. Dairy Sci.*, **33**: 758. 1950.

(9) Hibbs, J. W., Krauss, W. E., Monroe, C. F., and Sutton, T. S. Studies on Milk Fever in Dairy Cows. I. The Possible Role of Vitamin D in Milk Fever. *J. Dairy Sci.*, **29**: 617. 1946.

(10) Hibbs, J. W., Krauss, W. E., Pounden, W. D., Monroe, C. F., and Sutton, T. S. Studies on Milk Fever in Dairy Cows. II. The Effect of Vitamin D on Some of the Blood Changes in Normal and Milk Fever Cows at Parturition. *J. Dairy Sci.*, **34**: 767. 1946.

(11) HIBBS, J. W., POUNDEN, W. D., AND KRAUSS, W. E. Studies on Milk Fever in Dairy Cows. III. Further Studies on the Effect of Vitamin D on Some of the Blood Changes at Parturition and the Composition of Colostrum in Normal and Milk Fever Cows. *J. Dairy Sci.*, **34**: 855. 1951.

(12) POUNDEN, W. D., AND HIBBS, J. W. Unpublished data.

(13) SMITH, C. R., CHAMBERLAIN, D. M., HIBBS, J. W., KINGMA, F. J., AND COLE, C. R. (In preparation for publication.)

(14) TALMAGE, R. V., KRAINTZ, F. W., FROST, R. C., AND KRAINTZ, L. Evidence for a Dual Action of Parathyroid Extract in Maintaining Serum Calcium and Phosphate Levels. *Endocrinology*, **52**: 318. 1953.

(15) TAYLOR, N. B., WELD, C. B., BRANION, H. D., AND KAY, H. D. A Study of the Action of Irradiated Ergosterol and of Its Relationship to Parathyroid Function. *Can. Med. Assoc. J.*, **24**: 763. 1931.

(16) TAYLOR, N. B., WELD, C. B., AND SYKES, J. F. The Relation of the Parathyroid Glands to the Action of Irradiated Ergosterol. *Proc. Roy. Soc. (London)*, **116**: 10. 1934.

(17) TAYLOR, N. B., WELD, C. B., AND SYKES, J. F. Parathormone Tolerance in Dogs. *Brit. J. Exptl. Pathol.*, **17**: 104. 1936.

(18) WAGNER, A. R., COLE, C. R., AND HIBBS, J. W. (In preparation for publication.)

POSTPARTUM ESTRUS AND INVOLUTION OF THE UTERUS IN AN EXPERIMENTAL HERD OF HOLSTEIN-FRIESIAN COWS[1]

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Maintenance of regular calving intervals of desirable length constitutes satisfactory breeding efficiency in cows. It is dependent upon their being fertile when rebred at a suitable interval postpartum. Short intervals from calving to rebreeding, however, have not given the highest conception rates. The relatively poor results soon after calving are presumed to be caused by incomplete involution of the uterus at the time of breeding.

The present study is an analysis of some of the sources of variation in the intervals to involution and to first heat and of their potential relation to the time of rebreeding.

MATERIALS AND METHODS

The data were collected from the Holstein-Friesian herd stationed at the Emmons Blaine, Jr. Experimental Farm at Lake Mills, Wisconsin. The cows were all outbred animals. All calvings of such animals occurring between Dec. 21, 1949, and Dec. 20, 1953, (323 of them) were included for the study of the interval from parturition to completed involution of the uterus. Regular weekly palpations of the reproductive organs were made, beginning 15 to 21 days post-calving, and carried on until the uterus was involuted completely. Complete involution was judged by *(a)* return of the uterus to a normal location in the pelvic or near pelvic region, *(b)* normal and approximately equal size of the uterine horns (measured mesometrially—anti-mesometrially and also perpendicular to that measurement) with little further reduction in their size, and *(c)* attainment of the normal uterine tone and consistency.

The data for the study of interval from parturition to first succeeding estrus were gathered from cows calving normally (322 calvings) for the 6 years, 1948 to 1953, inclusive.

A cow was considered to have calved normally if a live calf was born 240 or more days from the date of breeding. Calvings involving twins, retained

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placenta, dystocia, prolapse of the uterus, a dead calf, or an abortion between 150 and 240 days from the date of conception were all considered as abnormal.

The 323 intervals from calving to involution of the uterus also were divided for purposes of analysis into those following normal calvings (252) and those following abnormal calvings (71).

Regular heat checks were made on all these cows twice daily by observations of behavior of the cows when turned into an exercise yard. In this herd efforts are made to keep environmental conditions as constant as possible. The cattle were not pastured but were fed silage and mixed legume hay throughout the year. As far as possible, one feeding of grass silage and one feeding of corn silage were provided each day while the hay was fed ad libitum.

The years under study were divided into four calving seasons—*(a)* winter, from Dec. 21 to March 20, *(b)* spring, from March 21 to June 20, *(c)* summer, from June 21 to Sept. 20, and *(d)* autumn, from Sept. 21 to Dec. 20.

The cows were also divided into two parity groups—primiparous and pluriparous. Cows that had calved only once were designated as primiparous and those that had calved twice or more were considered pluriparous (terms as used by Williams, *13)*.

The lengths of the interval from parturition to first heat and from parturition to involution of the uterus were analyzed for effects of season, parity, and interaction between parity and season. The presence of interaction was first tested by calculation of the sum of squares directly from sub-class numbers and means. No interaction being found, analysis was continued by a method appropriate when interaction is negligible with disproportionate sub-class numbers Snedecor *(11)*.

The test of significance for effect of season, parity, and interaction between season and parity on proportion of cows ready to breed at selected postpartum intervals was made by the method appropriate to analysis of chi-square as described by Rao *(9)*.

RESULTS

Interval following normal calvings. The average interval from parturition to involution of the uterus for cows that calved normally was 47 days (Table 1). The primiparous and pluriparous cows had their uteri involuted at average intervals of 42 and 50 days, respectively. The average intervals to involution including both parity groups were for cows calving in the winter, 51 days; in the spring, 47 days; in summer, 42 days; and in autumn, 44 days.

Variances in the intervals from parturition to involution of the uterus due to season and parity (Table 2) were significant (probabilities of 0.01 and 0.05, respectively). There was not a significant interaction between season and parity.

The average interval from parturition to first heat was 33 days (Table 1). The same average interval was observed for both primiparous and pluriparous cows. Disregarding parity and considering only the seasons, the average intervals to first heat for calvings during winter, spring, summer, and autumn were 38, 32, 28, and 32 days, respectively.

TABLE 1

Interval following normal calvings[a]

Seasons	Parity	Interval to first heat[b]		Interval to involution[c]		Per cent of animals coming in heat by a given interval postpartum[d]							Per cent of animals showing heat by a given interval postpartum that had involuted uteri[d]						
		No. of cows	Av. days	No. of cows	Av. days	(days) 30	45	60	75	90	105	120	(days) 30	45	60	75	90	105	120
Winter	Primiparous	36	39	26	44	46	65	85	92	100	100	100	8	38	69	88	96	100	100
	Pluriparous	54	37	53	54	38	79	87	92	100	100	100	0	30	60	77	94	100	100
Spring	Primiparous	46	34	30	44	43	77	93	100	100	100	100	7	43	90	100	100	100	100
	Pluriparous	53	32	51	52	57	84	94	96	98	98	100	8	39	69	78	94	96	98
Summer	Primiparous	28	28	17	42	82	94	94	94	94	94	100	18	71	82	88	94	94	100
	Pluriparous	40	28	36	42	58	83	94	100	100	100	100	5	61	92	100	100	100	100
Autumn	Primiparous	31	30	15	38	80	100	100	100	100	100	100	13	73	100	100	100	100	100
	Pluriparous	34	33	24	52	62	83	96	100	100	100	100	4	25	67	83	95	100	100
Winter	Primiparous and Pluriparous	90	38	79	51	40	75	86	92	100	100	100	2	33	63	81	95	100	100
Spring	"	99	32	81	47	52	72	94	97	99	99	100	7	41	76	86	96	97	99
Summer	"	68	28	53	42	66	87	94	98	98	98	100	9	64	89	96	98	98	100
Autumn	"	65	32	39	44	69	90	97	100	100	100	100	8	44	79	90	97	100	100
All seasons	Primiparous	141	33	88	42	58	81	92	97	99	99	100	10	52	84	94	98	99	100
	Pluriparous	181	33	164	50	52	82	92	96	99	99	100	4	39	71	83	96	99	99
Total		322	33	252	47	54	82	92	96	99	99	100	6	44	75	87	96	99	100

[a] Out of 324 normal calvings, two were not considered for interval from parturition to first heat since they showed abnormally long intervals (more than 6 to 7 standard deviations above the mean).

[b] S.D. = 18.7 within parity-season groups.

[c] S.D. = 16.7 within parity-season groups.

[d] Based on the numbers of cows indicated under interval to involution.

Analysis of variance indicated a highly significant difference among seasons, but the difference between parity groups and interaction between parity and season were not significant (Table 2). A slight association within the parity-

TABLE 2

Analysis of variance for intervals to first heat and to involution of the uterus

Source	d.f.	Mean squares	
		Interval to first heat	Interval to involution
Parity	1	6.9	3,525.2[b]
Seasons	3	1,345.8[b]	996.2[c]
Parity × seasons	3	130.7	358.1
Within subgroups	[a]	348.9	279.2

[a] 315 degrees of freedom for interval to first heat and 245 degrees of freedom for interval to involution.
[b] $P < 0.01$.
[c] $P > 0.01, < 0.05$.

season groups was found between the intervals to first heat and to the involution of the uterus ($r = 0.147$, $P = 0.05$).

Examination was made of the data on cows that had come into heat by the end of different intervals of time postpartum to determine the proportions of such cows whose uteri were involuted. The results are pertinent in determining the chances of a cow being ready to breed at different postpartum periods. Of all cows in heat after an interval of 30 days, 6% had their uteri involuted, 44% had them involuted at 45 days, 75% at 60 days, 87% at 75 days, 96% at 90 days, 99% at 105 days, and approximately 100% at 120 days (Table 1).

A greater percentage of the uteri of primiparous cows than of pluriparous cows was involuted at 30 days. Season and season × parity did not exert a significant effect at that stage (Table 3). A similar situation existed at 45 days

TABLE 3

Analysis of chi-square for the effect of parity, seasons, and interaction on the animals that came in heat and had their uteri involuted at given intervals postpartum

Source	d.f.	χ^2 at different intervals (days) postpartum				
		30	45	60	75	90
Parity	1	6.25[a]	5.65[a]	10.16[b]	11.75[b]	2.91
Seasons	3	4.86	11.01[a]	11.65[b]	9.71[a]	6.42
Parity × seasons	3	3.07	3.97	13.64[b]	15.06[b]	1.82

[a] $P > 0.01, < 0.05$.
[b] $P < 0.01$.

except that differences between seasons were significant but interaction was not. At 60 and 75 days, interaction was significant between parity and seasons. Although chi-square values for parity and season were significant, these values were not larger than the figure for interaction when tested by the variance ratio as suggested by Rao *(9)*. No significant differences were found at 90, 105, or 120 days.

Interval following abnormal calvings. The study of 71 abnormal calvings (Table 4) indicated that the postpartum interval to involution of the uterus

TABLE 4
Interval following abnormal calvings

Seasons	Primiparous			Pluriparous			Total		
	No. of cows	Av. interval to first heat	Av. interval to involution	No. of cows	Av. interval to first heat	Av. interval to involution	No. of cows	Av. interval to first heat	Av. interval to involution
		(days)	*(days)*		*(days)*	*(days)*		*(days)*	*(days)*
Winter	8	37	49	15	38	64	23	37	56
Spring	8	38	44	12	35	64	20	36	54
Summer	2	18	47	11	27	42	13	22	44
Autumn	5	44	51	10	29	52	15	36	51
Total	23	34	48	48	38	56	71	36	52

was 5 days longer than for the cows calving normally. The primiparous cows in this group also tended to involute earlier than the pluriparous group.

DISCUSSION

The average interval from parturition to involution of the uterus (47 days) in the group of cows in this study is considerably longer than the 26.2 days observed by Casida and Venzke *(1)* and 29.4 days observed by Casida and Wisnicky *(2)*, possibly in part, because of a more conservative technique for evaluating the involution of the uterus (uncoiling of the horns manually for more complete measurement and examination).

The average interval of 33 days from parturition to first heat calculated in this study is very close to the interval of 30 days obtained by Olds *et al. (8)* but does not agree with the findings of Casida and Wisnicky *(2)*, who reported an average interval of 60.4 days from parturition to first succeeding heat. The longer interval to first heat obtained by Casida and Wisnicky was possibly because the herd under study was an institutional farm herd where heat checks were not made as regularly and as intensively as in the experimental herd of this study. Furthermore, and perhaps more explanatory, the cows in the herd studied by them were milked three times a day as compared to a twice-a-day milking schedule for the cows used in this study. Clapp *(5)* observed that cows that were milked three and four times daily showed longer intervals to first heat than cows on a twice-a-day milking schedule. His study was made on the same herd studied earlier by Chapman and Casida *(4)*, who had observed a mean length of 69.3 days from parturition to first subsequent estrus.

Primiparous cows were found to involute faster than the pluriparous cows. Casida and Wisnicky *(2)* also observed a lesser interval for uterine involution in first calving intervals as compared to the second or later calving intervals. However, the difference observed by them was not significant.

Chapman and Casida *(3)* pointed out that shorter postpartum rest intervals may be the most profitable in terms of butterfat production per calving interval

day. However, short intervals may not be best for good breeding performance. Olds *et al. (8)* obtained highest conception rates (55%) from first services made at 50-75 days after calving. Edwards *(6)* reported fairly high conception rates (73.1%) to first mating at 61-90 days. VanDemark and Salisbury *(12)* found a very low percentage of conceptions when cows were bred less than 20 days after calving, and Shannon *et al. (10)* indicated that a minimum interval of 50 days from calving to first insemination was necessary for satisfactory fertility.

A highly significant difference among seasons in the interval from calving to first heat suggests a seasonal trend in spite of the constant environmental conditions maintained in the herd. The cows calving during summer tended to show estrus at an earlier interval than the cows calving during the other seasons, whereas those calving during winter had the longest interval to first heat postpartum.

Since, as indicated by various workers, higher conception rates are obtainable when the cows are rebred at an interval ranging from 50 to 90 days postpartum and since the data of this study indicate that the majority of the animals coming into heat by a postpartum interval of 90 days have their uteri involuted, the results are compatible with the hypothesis that involution of the uterus is necessary for a cow to conceive readily after parturition.

If there is the intention to delay breeding after calving until virtually all cows have completed the involution of the uterus, breeding should be delayed at least 90 days. If, however, it is desirable to breed back earlier, a routine examination of the uterus at the time of heat should be made. It would show the majority of cows ready to breed at 60-75 days, and breeding of the ones not yet involuted could be delayed.

A study needs to be made of the effects of breeding before the uterus is involuted; the occurrence of harmful effects needs to be tested. If there is no retardation of involution and if the chances of conception when the uterus does become involuted are not lessened, there may be situations from the herd standpoint in which it is desirable to start breeding early. This may be true in order to increase the proportion of the cows calving at a certain desirable season, even though the probability of conception is not maximal.

SUMMARY

A study of the intervals from parturition to involution of the uterus and from parturition to first heat was made respectively on 252 and 322 normal calvings in a Holstein-Friesian herd. The average interval to involution was 47 days, and that to first heat was 33 days. The difference in the involution interval between primiparous (42 days) and pluriparous (50 days) cows was highly significant, and significant differences were observed among seasons, being shortest in the summer and autumn. Cows calving during summer tended to come in heat earlier than those calving in the other seasons, whereas those calving during winter had the longest intervals from parturition to first heat. Examination of cows at the end of different intervals after calving showed that 95% or more of the cows in heat had their uteri involuted after an interval of

90 days. A slight association within the parity season groups ($r = 0.147$; $P = 0.05$) was found between intervals to first heat and to involution of the uterus. A study of 71 abnormal calvings indicated a little longer interval (5 days) to involution than for cows calving normally. The primiparous cows in this group also involuted earlier than pluriparous cows.

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REFERENCES

(1) Casida, L. E., and Venzke, W. G. Observations on Reproductive Processes in Dairy Cattle and Their Relation to Breeding Efficiency. *Proc. Am. Soc. Animal Production*, p. 221. 1936.

(2) Casida, L. E., and Wisnicky, W. Effects of Diethylstilbestrol Dipropionate upon Postpartum Changes in the Cow. *J. Animal Sci.*, 9: 238. 1950.

(3) Chapman, A. B., and Casida, L. E. Length of Service Period in Relation to Productivity and Reproductive Efficiency in Dairy Cows. *Proc. Am. Soc. Animal Production*, p. 66. 1935.

(4) Chapman, A. B., and Casida, L. E. Analysis of Variation in the Sexual Cycle and Some of Its Component Phases with Special Reference to Cattle. *J. Agr. Research*, 54: 417. 1937.

(5) Clapp, H. A Factor in Breeding Efficiency of Dairy Cattle. *Proc. Am. Soc. Animal Production*, p. 259. 1937.

(6) Edwards, J. Fertility in Cattle: Effect of Post-Partum Interval. *Vet. Record*, 62: 310. 1950.

(7) Hammond, J. *The Physiology of Reproduction in the Cow.* Cambridge Univ. Press. 1949.

(8) Olds, D., Morrison, H. B., and Seath, D. M. Efficiency of Natural Breeding in Dairy Cattle. Ky. Agr. Expt. Sta., *Bull.* 539. 1949.

(9) Rao, C. R. *Advanced Statistical Methods in Biometric Research.* John Wiley & Sons, Inc., New York. 1952.

(10) Shannon, F. P., Salisbury, G. W., and VanDemark, N. L. The Fertility of Cows Inseminated at Various Intervals after Calving. *J. Animal Sci.*, 11: 355. 1952.

(11) Snedecor, G. W. *Statistical Methods.* 4th ed. The Iowa State College Press, Ames. 1946.

(12) VanDemark, N. L., and Salisbury, G. W. The Relation of the Post-Partum Breeding Interval to Reproductive Efficiency in the Dairy Cow. *J. Animal Sci.*, 9: 307. 1950.

(13) Williams, W. L. *The Diseases of the Genital Organs of Domestic Animals.* George Banta Pub. Co., Menasha, Wis. 1943.

IMPROVING CURD-FORMING PROPERTIES OF HOMOGENIZED MILK[1]

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Homogenizing milk for cheese reduces fat losses in the whey *(6, 9, 12)* and decreases leakage of fat from cheese stored at high temperatures *(6, 11)*. Homogenization of milk influences its curd-forming properties with rennet. Trout *(10)* has reviewed this subject thoroughly. Gel strength is reduced and rate of coagulation is increased. Reduction in gel strength is directly related to the effectiveness of homogenizing.

Apparently no single explanation of the mechanism responsible for the lowering of gel strength by homogenization of the milk has been commonly accepted. One possibility is the adsorption of proteins on the newly created fat surfaces. Another suggestion is that fat disrupts the continuity of gel structure and that increasing the number of fat globules therefore increases the number of weak points.

Wilson and Johnson *(11)* and Nichols *(6)* studied the making of Cheddar cheese from homogenized milk as a means of decreasing leakage of fat from cheese exposed to above-normal temperatures. The difficulties encountered in curd making and handling they tried to minimize by homogenizing cream and then standardizing it with skimmilk to the percentage of fat desired. Their procedures are not used commercially for Cheddar cheese. The practice is used in making blue-mold cheese but for reasons other than conservation of fat.

Homogenizing cream does not give maximum dispersion of fat globules *(5)*. Nichols *(6)* observed that fat leakage from cheese made from homogenized cream mixed with skimmilk tended to increase with the extent of fat clumping. He added disodium phosphate or, preferably, sodium citrate to the cream before homogenization in order to obtain better emulsification.

If Cheddar cheese is to be made from homogenized milk, the success of the operation depends in part upon improving the gel strength obtained by rennet. This investigation indicates the possibility of achieving this objective by increasing the concentration of solids-not-fat in the milk after homogenizing.

EXPERIMENTAL METHODS

The mixed milk for this work came from the 25,000-lb. supply received daily at the manufacturing laboratory of Babcock Hall. It was homogenized at 60° C. and 2,500 lb. pressure in a Manton-Gaulin homogenizer just prior to its final heat treatment at 74° C. for 16 seconds in an HTST pasteurizer.

Coagulation measurements and tests for curd tension were made on this milk within 6 hours after pasteurizing. The milk was tempered to 30° C. for 30 min-

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[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

[2] Present address: Diversey Corporation, Chicago.

utes before testing. It was coagulated with liquid commercial rennet which had been freshly diluted with distilled water so that 1 ml. of the solution added to each 50 ml. of milk in the tests gave the equivalent of 6 oz. of extract in 1,000 lb. of milk.

Rate of rennet coagulation was determined by the rolling bottle technique *(8)*. The time for coagulation was recorded in revolutions, each of which approximated 4 seconds. Firmness of curd was measured by an apparatus, shown in Figure 1, that combined the techniques of Alleman and Schmid *(1)* and Hill *(3)*.

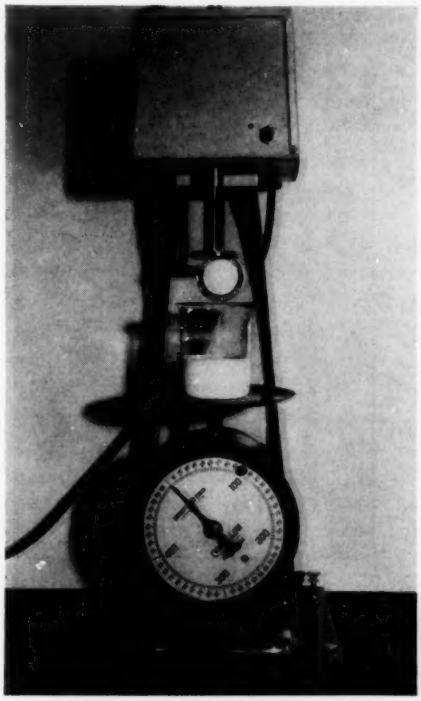

FIG. 1. The curd tension meter.

Cutting knife and driving mechanism were designed to meet the specifications of the Doan committee on curd tension *(2)*. Downward movement of the knife was 1 in. in 7 to 8 seconds, and time from adding rennet to curd tension measurement was 30 minutes.

RESULTS

The soft-curd properties of homogenized milk are well known *(10)*. During rennet coagulation this milk reacts to added calcium chloride and disodium phosphate as does nonhomogenized milk. Calcium chloride reduces the time of coagulation, and the first increments added produce the greatest reductions. Disodium phosphate increases the time of coagulation in direct proportion to the amounts

added to the homogenized milk. Typical measurements made in this laboratory are illustrated in Figure 2.

Homogenized milk, however, does not react as does the nonhomogenized product in developing gel strength. In normal milk, curd tension can be increased by adding calcium chloride; by increasing temperature of coagulation, amount of rennet, and time for rennet action; and by increasing the acidity of the milk at the time of adding rennet.

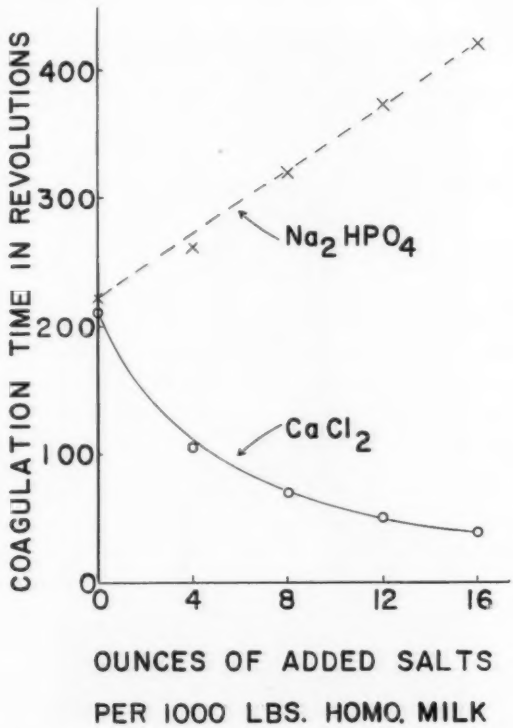

FIG. 2. The effect of added calcium chloride and disodium phosphate on the rate of coagulation of homogenized milk.

In these experiments calcium chloride did not restore the curd tension values lost by homogenizing even when added at more than double the rate permitted by federal standards for cheesemaking. In one typical trial the addition of 0, 2, 4, 6, and 8 oz. of this salt per 1,000 lb. of homogenized milk gave curd tension values of 8, 9, 11, 12, and 14 g., respectively. The curd tension of untreated, nonhomogenized milk taken from the identical milk supply approximated 25 to 30 g. during the period of these experiments.

Increasing the temperature of rennet action from the usual 30° C. to 40° C. produced curd tensions of only 7 or 8 g. in the homogenized milk curd. These

values were not increased by tripling the amount of rennet or by a threefold increase in time allowed for coagulation.

The acidity of coagulation was increased by adding dilute hydrochloric acid to the homogenized milk. When the pH values of the adjusted samples were 6.71, 6.61, 6.43, 6.30, and 6.14, the curd tension measurements were: 7, 8, 10, 12, and 12 g., respectively.

These common methods of increasing curd tension all failed to produce in homogenized milk sufficient gel strength for normal curd-making operations. The lack of response to these methods suggested the possibility of either a lack of available casein for curd formation or a mechanical interference with curd formation by increased numbers of fat globules in homogenized milk. Concentration of homogenized milk for gel strength tests seemed to be necessary to study these reactions.

Pasteurized, homogenized milk was concentrated at 57° to 60° C. in 1 hour to increase the solids-not-fat (SNF) content from 8.5 to 16.0% (1.88 to 1). Fat content was increased from 3.5 to 6.6%. The concentrate was cooled and tested immediately for curd tension. Six dilutions of the concentrate were made with distilled water so that SNF of the dilutions ranged downward to that of the original milk. The resulting curd tension measurements are shown in Figure 3.

Increasing the SNF of the homogenized milk by concentrating 1.88 to 1 increased the curd tension fivefold. In a similar trial in which concentration was 2.3 to 1 the increase in curd tension was tenfold. This value can be predicted by extrapolating the curve shown in Figure 3. Increases of SNF from 8.5 to 10.5% were less effective than increases beyond that zone of concentration. When the SNF of homogenized milk was increased by concentration, the rate of rennet coagulation remained practically unchanged. This is a surprising fact in view of the well known relation *(1)* between rate of coagulation and curd tension.

The results with milk concentration shown in Figure 3 suggested that the addition of low-heat, nonfat dry milk solids (NFDMS) to homogenized milk might produce similar improvement in gel strength. This was tried, and the results are plotted in Figure 3 for comparison with the data obtained by concentration. The addition of NFDMS to homogenized milk to increase curd tension was slightly more effective than milk concentration up to approximately the 13% level of SNF; beyond that zone, addition of NFDMS was slightly less effective than milk concentration.

Further observations showed that as the curd tension of homogenized milk was increased by concentrating the milk or adding NFDMS, there was a tendency for the milk to respond in gel strength like nonhomogenized milk to such factors as the addition of calcium chloride and duration of rennet action. The rate of coagulation remained unchanged at 171 to 163 revolutions (684 to 652 seconds) when SNF of homogenized milk was increased as much as 8% by adding NFDMS; curd tension values, however, increased fourfold from 11 g. for nonfortified homogenized milk to 43 g. for the same milk fortified with NFDMS.

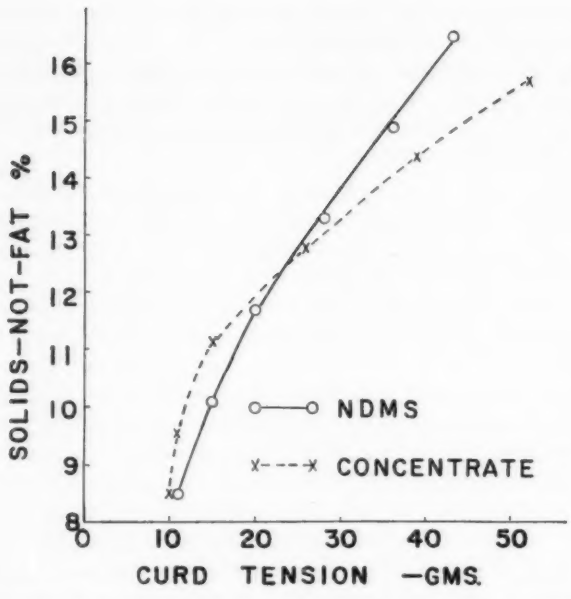

FIG. 3. The effects on curd tension of homogenized milk of increasing percentage of solids-not-fat by concentration of the milk and by adding nonfat dry milk solids.

A number of small vat lots of Cheddar, a soft-ripened cheese, and a cheese of the Pasta Filata type were made from concentrated homogenized milk and from homogenized milk fortified with small amounts of NFDMS or concentrated skimmilk. Gel formation was extremely rapid and firm. If allowed to become hard, the curd tended to fracture more than normally in cutting. Fat losses in the whey were 0.02-0.07%, or 10 to 20% of the normal values as measured by the Babcock test with the butyl alcohol modification. The curd lost moisture readily during the making operation at a rate comparable to that of the non-homogenized milk. The finished Cheddar cheese was very firm, yet higher in moisture (approximately 40%) than might have been expected from its body characteristics. Cut pieces of these cheese showed no visible leakage of fat when held on filter paper for 7 days at room temperature. Organoleptic observations of the 3-month-old Cheddar and Pasta Filata types of cheese showed that curing proceeded in the characteristic manner of low-moisture cheese made from pasteurized milk.

DISCUSSION

Homogenization decreases the time required for coagulation of milk by rennet. This effect might be explained by an increased adsorption of anions (citrates and phosphates) leaving calcium and magnesium to stimulate rate of coagula-

tion. This explanation is also suggested by the decreased heat stability *(4)* and alcohol stability *(7)* of homogenized milk.

The lowering of curd tension caused by homogenization of the milk indicates that coagulation rate and gel formation are not completely dependent upon the same factors. It is probable that this lowering of curd tension is caused by adsorption of casein on the newly formed fat surfaces. The increase of curd tension obtained by concentrating the homogenized milk suggests that the curd structure is strengthened by bringing closer together the casein particles still available for forming gel structure. Increasing curd tension by adding low-heat NFDMS to homogenized milk provides a greater concentration of gel-forming casein in the serum. The same effect was obtained by adding low-heat concentrated skimmilk to homogenized milk.

Restoration of curd-forming properties of homogenized milk opens new possibilities and, perhaps, economies in cheesemaking. It suggests new ways of reclaiming excess supplies of homogenized milk. Fat losses in the whey of normal making operations can be reduced. Losses of fat from hot curd during the molding of Pasta Filata types of Italian cheese can be minimized. Control of leakage of fat from cheese held at abnormally high temperatures seems to be feasible. It is possible that the use of cheese made from homogenized milk may affect the dispersion of fat in cheese-processing operations. Studies of these possibilities will be continued.

SUMMARY

The factors which alter the rate of rennet action and curd tension of non-homogenized milk have a similar action on rate of coagulation but very little or no effect on the curd tension obtained by rennet action on homogenized milk.

Practically normal curd-making properties were restored to homogenized milk by concentrating it or by adding to it low-heat, nonfat dry milk solids or low-heat concentrated skimmilk. The treatments may have practical commercial applications.

These data suggest that reduction of curd tension by homogenizing may be caused by adsorption of casein on the newly created surfaces of fat.

REFERENCES

(1) ALLEMAN, O., AND SCHMID, H. Uber die Festigkeit des durch Lab erzeugten Milchkoagulums. *Landwirtsch Jahrb. Schweiz.*, **30**: 355. 1916.

(2) DOAN, F. J., BABCOCK, C. J., CHAMBERS, L. A., FLORA, C. C., HULL, M. E., MUELLER, W. S., SOMMER, H. H., AND STORRS, A. B. Final Report of Committee on Methods of Determining the Curd Tension of Milk. *J. Dairy Sci.*, **24**: 825. 1941.

(3) HILL, R. L. A Test for Determining the Character of the Curd from Cows' Milk and Its Application as an Index to the Food Value of Milk for Infants. *J. Dairy Sci.*, **6**: 509. 1923.

(4) HUNZIKER, O. F. *Condensed Milk and Milk Powder.* 6th ed. Published by the author, LaGrange, Ill. 1946.

(5) MAXCY, R. B., AND SOMMER, H. H. Fat Separation in Evaporated Milk. III. *J. Dairy Sci.*, **37**: 1061. 1954.

(6) NICHOLS, L. E. The Manufacture of Nonfat-Leaking Cheddar Cheese from Reconstituted Milk. *Queensland J. Agr. Sci.*, **5**: 39. 1948.

(7) SOMMER, H. H., AND BINNEY, T. H. A Study of the Factors that Influence the Coagulation of Milk in the Alcohol Test. *J. Dairy Sci.*, **6**: 176. 1923.

(8) SOMMER, H. H., AND MATSEN, HELENE. The Relation of Mastitis to Rennet Coagulability and Curd Strength of Milk. *J. Dairy Sci.*, **18**: 741. 1935.

(9) STEVENSON, A. F. (assignor to Borden Co.) Manufacture of Cheese from Homogenized Milk. U. S. Patent 1,868,547. July 26, 1932.

(10) TROUT, G. M. *Homogenized Milk.* p. 30. Michigan State College Press, East Lansing. 1950.

(11) WILSON, H. L., AND JOHNSON, W. T. (to the free use of the people of the United States) Process to Prevent the Oiling Off or Leakage of Butterfat in Cheese. U. S. Patent No. 2,127,453. August 16, 1938.

(12) ZOLLIKOFER, E. Der Einfluss der Homogenisation auf die Labfähigkeit der Milch und den Fettgehalt der Käsemolke. *Proc. 12th Intern. Dairy Congr.*, **3**: 129. 1949.

LIPASE SYSTEMS USED IN THE MANUFACTURE OF ITALIAN CHEESE. I. GENERAL CHARACTERISTICS [1] [2]

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In the traditional method of manufacturing Provolone and Romano cheese crude rennet pastes are used. The importance of these pastes to characteristic flavor development in the cheese has been demonstrated in recent work, and this effect has been attributed to lipase supplied by these products *(4, 9)*. Since these crude rennet pastes are generally considered unacceptable because of their impurity, cheesemakers in this country have utilized a variety of other enzyme products. The success of these products in duplicating the characteristic flavor which results from the use of rennet pastes has been shown to depend upon the presence of fat-splitting enzyme systems *(4)*. More specifically, evidence has been obtained which indicates that the importance of rennet pastes and other enzyme products is related to the production of free butyric acid resulting from lipase action *(5)*. Limited evidence has revealed that some lipases, such as pancreatic, cannot be utilized successfully in the manufacture of Italian cheese *(4)*.

In order to make obviously needed improvements in the character of rennet pastes from the standpoint of sanitary and esthetic properties, it is first necessary to determine the basic characteristics of the lipase system of the rennet pastes. Purified rennet pastes and other commercial lipase preparations also are available, and a study of the lipase systems of these products also is needed.

The principal objective of this investigation was to study and to compare the characteristics of the lipase systems of the various enzyme preparations available which may be used in the manufacture of Italian type cheese.

EXPERIMENTAL PROCEDURE

Materials and methods: Ten enzyme materials from calf, kid, and lamb sources were compared. These are identified in Table 1. The composition of these products was reported in an earlier paper *(6)*. All preparations were stored at 5° C. until ready for use.

The milkfat substrate employed throughout these studies was cream containing 20% milk fat separated from fresh milk. Because of the presence of lactose-fermenting organisms in some of the commercial paste preparations, the cream was dialyzed prior to use in order to minimize bacterial growth during

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TABLE 1

Identification of enzyme preparations used for Italian type cheese

No.	Animal source	Description of product
1	Kid	Laboratory-prepared crude rennet paste
2	Calf	Laboratory-prepared crude rennet paste
3	Kid	Imported crude rennet paste
4	Mixed; unknown	Imported crude rennet paste
5	Unknown	Domestic purified rennet paste
6[a]	Lamb	Domestic glandular enzyme preparation
7[a]	Kid	Domestic glandular enzyme preparation
8[a]	Calf	Domestic glandular enzyme preparation
9	Calf	Domestic purified rennet paste
10	Calf	Domestic purified rennet paste

[a] These preparations are manufactured from a gland in the pharyngeal region of the esophagus *(2)*.

lipase studies. A Webb-Cell continuous dialyzer was employed, and dialysis was conducted at 5° C. until a negative Fehling's test for lactose was obtained. The dialysis did not depress the lipase activity of any of the enzyme preparations. Toluene, used in 1/1000 dilutions, did not inhibit lipase activity. This preservative was used to inhibit spore-forming organisms in certain enzyme preparations which were found to grow in the absence of lactose.

Phosphate and phthalate buffers *(1)* were used in sufficient strength to minimize pH changes during the incubation period. Acetate and citrate buffers could not be used, since the microorganisms present in some of the enzyme preparations were found to utilize these compounds for growth.

Lipase activity was determined by a measurement of free fatty acids, which were determined by titrating a solvent extract of the cream *(11)*. Controls containing the substrate and buffer mixture were incubated with the samples in all trials. All results are reported as averages of duplicate trials and are expressed as increase in the titre in milliliters N/100 base per gram of fat.

Reaction mixtures contained 45 ml. of substrate-buffer mixture and the commercial enzyme preparation in 5 ml. of buffer to give a final volume of 50 ml. In all trials 1% of enzyme preparation was present in the total reaction mixture, and the substrate was always present in excess. The excess substrate concentration for each enzyme preparation was determined by increasing the substrate concentration until additional quantities caused no corresponding increase in enzyme activity.

In obtaining data to establish the proper time-temperature relationship of incubation for future kinetic studies of the enzyme systems, analyses were made at both pH 5.3 and pH 6.6. The reaction rates in respect to time and temperature were shown to have similar relationships at both pH 5.3 and pH 6.6. Since the primary interest in this study was in the action of the enzyme preparations at the pH of cheese, data are presented for analyses at pH 5.3.

Effect of time on lipase activity. In order to establish when the reaction rates would remain constant in respect to time of incubation, analyses for acidity changes were made after incubation at 32° C. for 0, 1, 2, 4, 6, 8, 10, 18, and 22 hours. Data are presented in Figure 1.

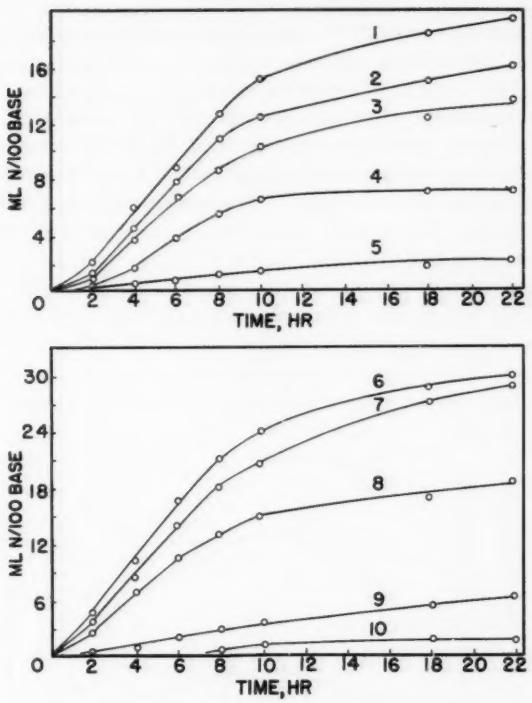

FIG. 1. Relationship of time to lipase activity of the various enzyme preparations. 1. Imported crude kid rennet paste. 2. Laboratory prepared crude kid rennet paste. 3. Laboratory prepared crude calf rennet paste. 4. Imported crude rennet paste from mixed animal sources. 5. Purified domestic rennet paste. 6. Glandular lamb enzyme preparation. 7. Glandular kid enzyme preparation. 8. Glandular calf enzyme preparation. 9. Purified domestic calf rennet paste. 10. Purified domestic calf rennet paste.

These results reveal that the reaction rates for the majority of the products were constant in respect to time, i.e., between 2 and 6 hours of incubation. The lipolytic activity of the glandular enzyme products per unit weight of product (curves 6, 7, and 8) was always considerably greater than that for the other enzyme preparations.

The purified rennet paste preparations (curves 5, 9, and 10) had considerably less lipase activity than the other preparations. The purified rennet pastes 9 and 10 were not studied further in any investigations at pH 5.3 because of their low lipase activity. A lag was noted in the lipase activity of all of the rennet paste preparations on initiating activity. This delay was generally less in the glandular preparations. The animal source did not influence the time-reaction rate relationship. In all further studies incubation times were maintained between 4 and 6 hours.

Effect of incubation temperature on lipase activity. The influence of temperature, between 20° and 40° C., on lipase activity was determined for the various enzyme preparations. All the trials were conducted at pH 5.3 with an incubation time of 5 hours. The results, which are presented in Figure 2, reveal that temperature optima for lipolysis were between 29° and 35° C. for the various preparations. Rennet paste preparations had a broader temperature optima range and higher temperature optima than did the commercial glandular preparation from the same type of animal. The reason for these differences is not readily apparent, but they may be explained by the higher lipase concentration in the glandular preparations.

For most preparations the activity decreased more rapidly above the temperature optima than it did below the optima. The decrease in temperature stability at the higher temperatures is the most logical explanation of this observation.

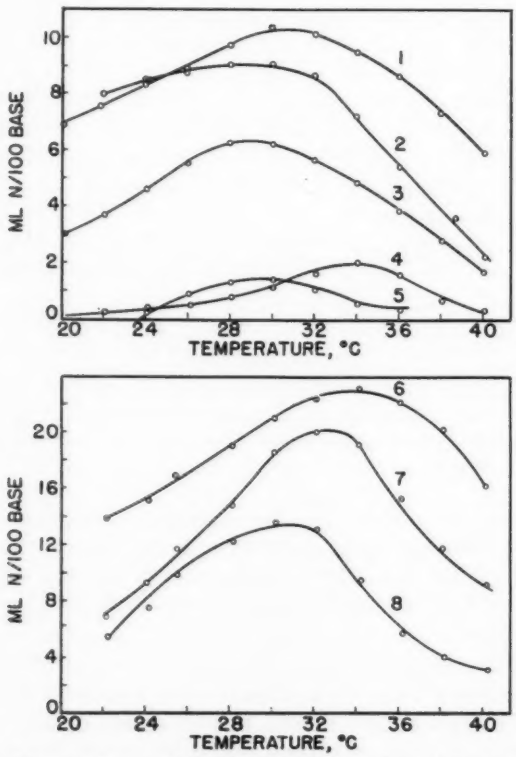

FIG. 2. Effect of temperature on lipase activity of the various enzyme preparations. (Incubation time, 5 hr.; pH = 5.3). 1. Imported crude kid rennet paste. 2. Laboratory prepared kid rennet paste. 3. Laboratory prepared calf rennet paste. 4. Purified domestic rennet. 5. Imported crude rennet paste from mixed animal sources. 6. Glandular lamb preparation. 7. Glandular kid preparation. 8. Glandular calf preparation.

Effect of pH on lipase activity. The effect of pH on lipase activity of the various enzyme preparations was determined. The phthalate buffer was used between pH 5.0 and 6.8, and the phosphate buffer between pH 6.2 and 9.0. The ionic strength of the buffer was maintained constant in these trials. The terminal values did not vary over 0.10 pH unit from initial values with the phthalate buffer but varied up to 0.2 pH with the phosphate buffer. The activity values obtained with phthalate buffer between pH 6.2 and 6.8 were the same as for phosphate buffer in the same pH range. The data are presented graphically in Figures 3 and 4.

A comparison is shown in Figure 3 of the pH activity curves of laboratory prepared kid and calf rennet pastes (curves 1 and 2) and kid and calf glandular preparations (curves 3 and 4). The curves reveal that the preparations from

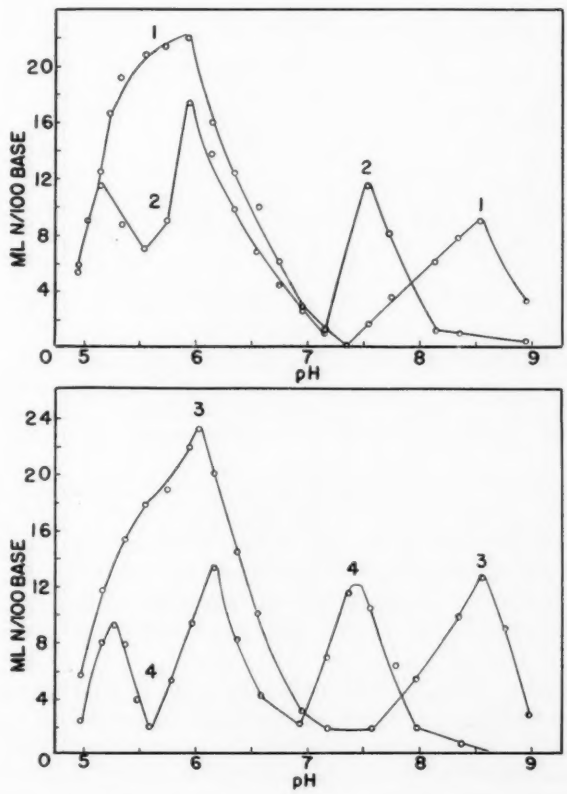

FIG. 3. Effect of initial pH on lipase activity of four of the various enzyme preparations. (Incubation time, 5 hr.; temperature, 32° C.) 1. Glandular kid enzyme preparation. 2. Glandular calf enzyme preparation. 3. Laboratory prepared crude kid rennet paste. 4. Laboratory prepared crude calf rennet paste.

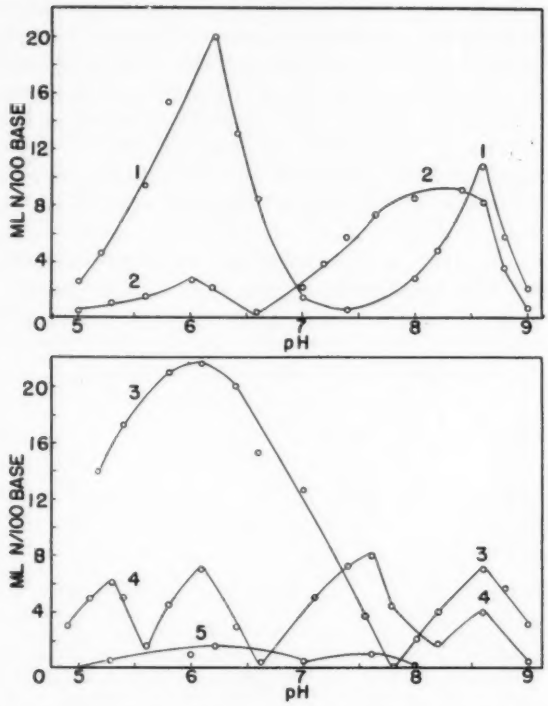

FIG. 4. Effect of initial pH on lipase activity of five of the enzyme preparations. (Incubation time, 5 hr.; temperature, 32° C.) 1. Imported crude kid rennet paste. 2. Purified domestic rennet paste. 3. Glandular lamb enzyme preparation. 4. Imported crude rennet paste from mixed animal sources. 5. Purified calf rennet paste.

different animal sources definitely differ as to their pH-reaction rate relationships. The calf product has three pH optima of activity, at 5.3, 6.2, and 7.5, whereas the kid preparation has pH optima at 6.2 and 8.5. The shape of the curve for the kid lipases below pH 6.0 suggests the possible presence of a third lipase. The activity of the pastes and the glandular materials from the same animal are similarly affected by pH, indicating that the same lipase systems are present.

The pH activity curves for four rennet pastes and a glandular lamb preparation are shown in Figure 4. The glandular lamb enzyme system (curve 1) has a rather broad pH optima, between 5.8 and 6.4, and a second optima at 8.6. The crude rennet pastes from specific animal sources exhibit the same pH-activity relationship revealed by similar products in Figure 3. However, the curve for imported crude rennet paste of mixed animal sources shows the presence of four pH optima.

Results for two of the purified rennet pastes are also shown in Figure 4

(curves 2 and 5). The lipase activity represented in curve 5 was very low and exhibited a pH optimum between 5.9 and 3.3. In the other purified paste (curve 2) the main pH optimum was at 8.6, and there was very little activity at pH 5.3.

The much lower activity in the purified products, as compared to the crude materials from which they came, indicates that the process of purification removes an appreciable portion of the lipase. The unexpected high activity at pH 8.5 for the one purified paste (curve 2) suggests that this preparation probably contains an added lipase, such as pancreatic lipase.

Effect of substrate concentration on lipase activity. The reaction rates of the enzyme preparations at various substrate concentrations were determined. The substrate was varied to contain from 1 to 20% fat in the final reaction mixture. Phthalate buffer at pH 5.3 was used to maintain the pH, and the samples were incubated for 5 hours at 32° C.

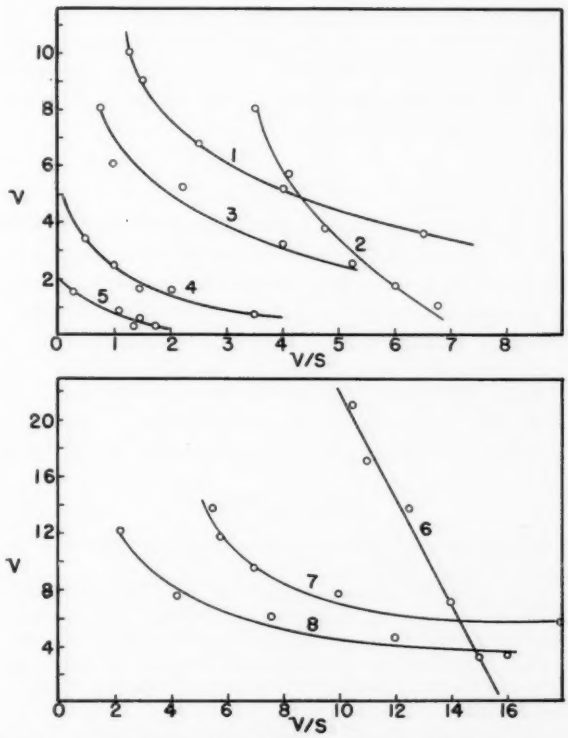

FIG. 5. Effect of substrate concentration on lipase activity of the various enzyme preparations. (Velocity in ml. of N/100 base/g. Substrate in g. fat/g. reaction mixture. Incubation time 5 hr.; temperature, 32° C.; pH, 5.3). 1. Imported crude kid rennet paste. 2. Imported crude rennet paste from mixed animal sources. 3. Laboratory prepared kid rennet paste. 4. Laboratory prepared calf rennet paste. 5. Purified domestic rennet paste. 6. Glandular lamb preparation. 7. Glandular kid preparation. 8. Glandular calf preparation.

Hofstee *(7)* has rearranged the Michaelis-Menten equation ($v = \frac{VS}{S + Km}$) to give the linear equation ($V = v + vKm/S$). When the reaction rate *(v)* is plotted against the reaction rate divided by substrate concentration (v/S), the presence of more than one enzyme is represented by a curved line. The Hofstee plot for this experiment, presented in Figure 5, reveals that at pH 5.3 only lamb glandular lipase shows a straight line relationship, indicating one lipase. For all calf and kid products, the plot is a curved line, indicating the presence of more than one lipase in all preparations containing enzymes from either calf or kid sources. The curved plot for the kid product, which suggests two lipases active at pH 5.3, is of interest, since only one distinct pH optimum was observed below pH 7.0.

The cumulative data provide a sound basis for the statement that the lipase systems of the glandular preparations and rennet pastes from the same animal are identical.

The physiological significance of the glandular lipase should be of interest. It is possible that these lipases are the source of "pregastric" lipolysis noted in the "sham feeding" trials of Wise *et al. (12)*. Studies on the physiological significance of these preparations might provide valuable information concerning the nutrition of young ruminants.

SUMMARY

The general characteristics of the lipase systems of ten preparations used in the manufacture of Italian cheese were investigated in respect to activity at various temperatures, pH levels, and substrate concentrations. The results of pH and substrate concentration studies revealed that each of these preparations probably contained a multiple lipase system and that these systems were the same for products from the same animal source. The calf products were found to have three lipases with pH optima at 5.3, 6.1, and 7.5; the kid products had three lipases with pH optima of 8.6, 6.2, and between 5 and 6; the one lamb preparation exhibited two lipases with optimum activity at pH 5.9 and 6.6.

REFERENCES

(1) Clark, W. M. *The Determination of Hydrogen Ions.* 3rd ed., p. 221. The Williams and Wilkins Company, Baltimore. 1929.

(2) Farnham, M. G. Cheese Modifying Enzyme. U. S. Patent No. 2, 531, 329. Nov. 21, 1950.

(3) Harper, W. J., and Gould, I. A. Italian Cheese Ripening: I. Composition of Commercial Provolone and Romano Cheese. *Butter, Cheese, Milk Products J.*, **43** (5): 24. 1952.

(4) Harper, W. J., and Gould, I. A. Italian Cheese Ripening: II. Relationship of Type of Enzyme Product to the Ripening of Romano and Provolone Cheese. *Butter, Cheese Milk Products J.*, **43** (8): 22. 1952.

(5) Harper, W. J., and Long, J. E. Italian Cheese Ripening: IV. Various Free Amino Acids and Free Fatty Acids in Commercial Provolone Cheese. In press. 1954.

(6) Harper, W. J., Maskell, K. T., and Hargrove, R. E. Italian Cheese Ripening: Chemical Composition and Bacteriological Flora of Rennet Pastes and Related Preparations. *Butter, Cheese Milk Products J.*, **43** (12): 20. 1952.

(7) Hofstee, B. H. J. Specificity of Esterases. I. Identification of Two Pancreatic Aliesterases. *J. Biol. Chem.*, **199**: 357. 1952.

(8) JOHNSON, B. C., AND GOULD, I. A. Milk Lipase System: III. Further Studies of the Solvent Extraction Procedure for Obtaining Milk Fat for Titration. *J. Dairy Sci.*, 32: 447. 1949.

(9) MATTICK, J. F., DAHLE, C. D., AND WATROUS, G. H., JR. Romano Type Grating Cheese. Pa. Agr. Expt. Sta., *Bull.* 537. 1951.

(10) PHILLIPS, C. A., RICHARDSON, G. A., AND TARASSUK, N. P. The Use of Rennet Paste in Romano Type Cheese. *J. Dairy Sci.*, 25: 728 (abs.). 1942.

(11) THOMAS, W. R., HARPER, W. J., AND GOULD, I. A. Free Fatty Acids in Fresh Milk as Related to the Portion of Milk Drawn. *J. Dairy Sci.*, 37: 717. 1954.

(12) WISE, G. H., MILLER, P. G., AND ANDERSON, G. W. Changes Observed in Milk "Sham Fed" to Dairy Calves. *J. Dairy Sci.*, 23: 997. 1940.

OBSERVATIONS ON THE ACETATE AND CITRATE METABOLISM OF *STREPTOCOCCUS LACTIS* AND *STREPTOCOCCUS CREMORIS*[1]

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The vitamin requirements of a number of *Streptococcus lactis* cultures were studied by Niven *(5)* in a medium containing acid hydrolyzed casein. He reported that all of the cultures tested required biotin, nicotinic acid, pantothenate, and thiamine. Approximately one-third of the cultures tested required riboflavin; none of the cultures showed a requirement for pyridoxine or folic acid. Later Anderson and Elliker *(1)* made a similar study on a number of cultures, the majority of which were *Streptococcus cremoris*. Their study revealed a requirement for biotin, pantothenate, and niacin; riboflavin again was required by some of the strains studied. Collins *et al. (2)* encountered difficulty in culturing some strains of *S. lactis* and a number of strains of *S. cremoris* in the medium of Niven. They found, however, that additions of acetate and a source of the oleate radical to this medium permitted growth of the more fastidious strains.

Preliminary data in this laboratory confirmed the observations of Collins *et al. (2)* concerning acetate and also indicated a possible greater importance of citrate. The purpose of this investigation was to study the effect of acetate and citrate upon the growth of strains of *S. lactis* and *S. cremoris* and to ascertain whether the response to these metabolites correlated with other characteristics of the two species.

EXPERIMENTAL PROCEDURE

The synthetic medium used throughout the investigation was essentially that of Henderson and Snell *(3)*. The modifications of Anderson and Elliker *(1)* were adopted with the exception that the ascorbic acid level was lowered to 20 mg. per 100 ml. of medium. A further modification of this medium was effected to give three test media. In the first, the citrate level was reduced to 10 mg. per milliliter and acetate was deleted; this will be referred to as the "citrate treatment." In the second, citrate was deleted and the acetate level was increased to 10 mg. per milliliter; this will be referred to as the "acetate treatment." In the third, both acetate and citrate were deleted, and this medium will be referred to as the "control treatment."

The stock cultures used in this study were carried in litmus milk. The cultures were routinely transferred every 7 days using 1% inoculum and incubation for 24 hours at 32° C., followed by refrigeration between transfers. Inocula for the synthetic media consisted of a fresh 24-hour culture grown in litmus milk.

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In testing the requirements of the cultures for various compounds, each medium tested was inoculated initially from a 24-hour litmus milk culture, using 0.05% inoculum and incubation at 32° C. for 24 hours. This was followed by two serial 24-hour subcultures in the same medium, using 0.05% of the previous 24-hour culture for inoculum. Cultures were tested in 2 ml. of medium, and inoculation was with a calibrated 0.001-ml. platinum loop. Incubation was 32° C. for 24 hours for each transfer. The data reported throughout this paper were recorded from the growth response of the organisms in the third serial culture grown in synthetic medium. This culturing sequence imposed a 2,000-fold dilution of the inoculum per culture, thus adequately eliminating any response due to metabolite carry-over from the initial litmus milk inoculum.

Growth in the synthetic media was determined turbidimetrically by means of a model No. 401 Lumetron colorimeter equipped with a 550-mμ filter and expressed as per cent light transmission.

Cultures used in this study were obtained from various sections of the country to give a geographical distribution of sources. The cultures were placed into two groups of statistical analysis based on their fermentation of maltose and growth at 40° C. Strains that utilized maltose and grew at 40° C. were placed in Group A *(S. lactis)*. Strains that did not utilize maltose and did not grow at 40° C. were placed in Group B *(S. cremoris)*.

The data from the various treatments were subjected to statistical analysis. The data from the response of the Group A strains were subjected to three comparisons: control treatment versus acetate treatment; control treatment versus citrate treatment; acetate treatment versus citrate treatment. The data from the response of the Group B strains were subjected to only two comparisons: control treatment versus acetate treatment and control treatment versus citrate treatment. The *t* test on difference was employed in order to eliminate variation in response due to strains.

RESULTS

Preliminary results with a strain of *S. cremoris* (No. 1) and a strain of *S. lactis* (No. 144-F) indicated a definite difference in their response to acetate and citrate. Figure 1 shows the response of *S. cremoris* (No. 1) to increments of acetate in the presence and absence of citrate. The results revealed that in the absence of citrate, the optimal acetate level was 3 mg. per milliliter of medium, with a gradual reduction in response occurring between the levels of 3 mg. and 15 mg. per milliliter. The inclusion of citrate in the medium, irrespective of the acetate level, retarded growth to the extent that the transmission value did not exceed 96.5%. In view of subsequent observations subjected to statistical analyses, this amount of growth was of no significance.

On subjecting the strain of *S. lactis* (No. 144-F) to similar treatments, the results were essentially diametrically opposed to those found for the *S. cremoris* strain with respect to the effect of citrate. The maximum growth in the absence of citrate (Figure 2) gave a light transmission of 65%; in the presence of 10 mg.

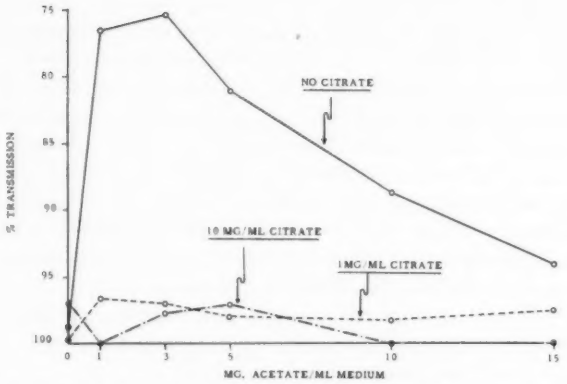

FIG. 1. Effect of acetate level upon the growth of a Group B lactic streptococcus *(S. cremoris* No. 1) in the presence and absence of citrate.

per milliliter of citrate, the maximum was 50.75%. The addition of 1 mg. of acetate per milliliter increased the growth response in the absence of citrate but did not have any appreciable effect when citrate was present. Levels of acetate in excess of 1 mg. per milliliter were inhibitory in the absence or presence of citrate.

It appeared that the response of *S. lactis* and *S. cremoris* to acetate and citrate might well be correlated with species classification. It was immediately apparent that all possible levels of citrate and acetate, between zero and 20 mg. per milliliter could not be tested expediently. Therefore, screening experiments were conducted on eight cultures, four *S. lactis* and four *S. cremoris,* to ascertain levels of acetate and citrate that would prove satisfactory for testing a large number of organisms. The screening experiments revealed that 10 mg. per milli-

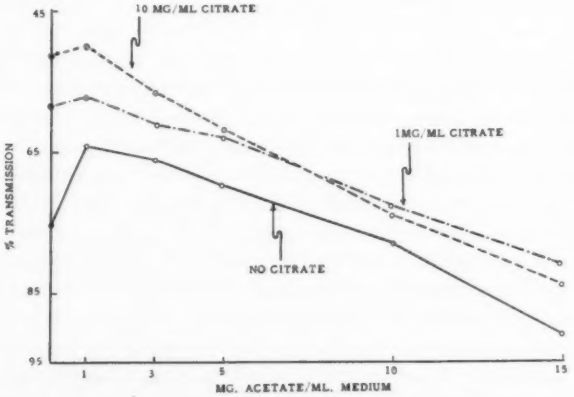

FIG. 2. Effect of acetate level upon the growth of a Group A lactic streptococcus *(S. lactis* No. 144-F) in the presence and absence of citrate.

liter of either acetate or citrate would be satisfactory for testing the larger numbers of organisms. Calculation of a probable number based on the variance experienced in the screening experiments revealed that approximately 12 cultures would have to be tested to show a significant difference between the acetate treatment and the citrate treatment. Thus, these levels were selected and constituted the basis for the formulation of the acetate treatment, citrate treatment, and control treatment.

TABLE 1

The response of the Group A strains to acetate, citrate, and control treatments

Strain	Control treatment	Per cent transmission	
		Acetate treatment	Citrate treatment
		(av.)	*(av.)*
126	63.25	60.25	43.50
24	63.50	52.75	36.50
MS	61.75	57.00	41.25
UM	88.00	73.75	49.25
4	62.75	56.75	33.00
29	69.25	49.75	43.00
51	56.00	46.50	30.50
E	63.50	53.00	45.75
144-F	76.50	76.37	57.37
27	75.00	48.50	42.50
RS	62.50	51.00	33.50
WS	57.25	48.75	41.00
JM	62.50	49.00	39.50
YAR	75.75	51.75	42.00
Mean	66.96	55.36	41.33
t		3.2996[a]	8.266[a]

[a] Significant at the 0.01 level.

Upon subjecting the Group A strains (organisms that utilized maltose and grew at 40° C.) to the citrate, acetate, and control treatments (Table 1), the results showed that all the strains manifested the greatest growth response in the presence of citrate. Statistical treatment of these data showed that a comparison between the citrate treatment and the control treatment gave a *t* value that was significant at the 0.01 level. A comparison beween the acetate treatment and the control treatment also yielded a *t* value having significance at the 0.01 level. A further comparison between the citrate treatment and the acetate treatment showed that the response to citrate was significantly greater than the response to acetate when tested at the 0.01 level of confidence.

The Group B strains (organisms that did not utilize maltose and did not grow at 40° C.), when subjected to the same treatments, gave results which showed that, with but one exception, all the strains responded more favorably to the acetate treatment (Table 2). The exception, strain 122-1, responded equally well to acetate and citrate. These data were also analyzed statistically, with the result that the only comparison showing significance was the control treatment versus the acetate treatment, which was significant by the *t* test at the 0.5 level of confidence.

TABLE 2

The response of the Group B strains to acetate, citrate, and control treatments

Strain	Control treatment	Per cent transmission	
		Acetate treatment	Citrate treatment
		(av.)	*(av.)*
SL-5	91.75	94.50	97.00
1-A	94.00	72.00	99.50
1	75.00	57.75	97.00
262	86.50	74.00	80.25
122-1	85.37	71.25	70.13
H-1-10	98.10	73.00	100.00
ML-1	87.00	58.75	66.87
Mean	88.25	71.61	87.25
t		2.8208[a]	0.1545

[a] Significant at the 0.05 level.

Since pantothenate is an integral part of the structure of coenzyme A, and since coenzyme A has been shown to operate actively in the metabolism of acetate and citrate *(4)*, it appeared advisable to evaluate the relative activity of pantothenate and coenzyme A for these organisms in the presence of acetate and citrate.

In the absence of pantothenate (Table 3) none of the strains tested was able to grow in either the acetate treatment or the citrate treatment. With panto-

TABLE 3

The effect of coenzyme A as a source of pantothenate in the growth of the lactic group of streptococci in the presence of acetate or citrate

Strain No.	Ca pantothenate	Coenzyme A	Citrate 10 mg/ml	Acetate 10 mg/ml
	(γ/ml)		*(av. % transmission)*	
144-F	—	—	100.00	100.00
	100	—	54.00	92.00
	—	100	100.00	97.50
ML-1	—	—	100.00	99.25
	100	—	100.00	63.75
	—	100	100.00	84.25
122-1	—	—	100.00	100.00
	100	—	79.75	71.50
	—	100	100.00	97.75
H-1-10	—	—	100.00	97.75
	100	—	100.00	76.00
	—	100	100.00	100.00
262	—	—	100.00	98.75
	100	—	100.00	79.00
	—	100	100.00	96.25
E	—	—	100.00	97.25
	100	—	41.00	56.25
	—	100	100.00	76.00

thenate present in the citrate treatment only three of the strains grew; these were 144-F, E, and 122-1. The first two were Group A organisms; the latter, a Group B strain that responded to both acetate and citrate. In the presence of citrate none of the organisms was able to grow when pantothenate was replaced by coenzyme A. In the presence of acetate only two strains, ML-1 and E, showed appreciable growth when coenzyme A replaced pantothenate.

DISCUSSION

The report of Collins *et al. (2)* emphasized the importance of acetate in the cultivation of lactic streptococci in synthetic media. Using the medium of Niven *(5)*, they found that of 22 strains tested all failed to grow in 24 hours without supplementation by either acetate or an oleate source.

The present study not only confirmed this observation but also indicated a possible greater importance of citrate. Without exception, the Group A strains *(S. lactis)* responded to citrate to a greater extent than they did to acetate. The reverse situation was encountered with the Group B strains *(S. cremoris)*; with some strains citrate proved to be definitely inhibitory. The contention that two distinct species exist in the lactic group of streptococci is supported by the statistical analysis of the data obtained when the citrate treatments were compared with the control treatments in both groups of cultures. This indicates that in addition to the definitive characteristics previously established, there exist further differences in the carbon metabolism of these two species.

The nature and site of the differences in response of *S. cremoris* and *S. lactis* to acetate and citrate can not be determined from the data presented in this paper. The data do allow speculative inference of possible sites of activity in the two species. The general area of carbon metabolism in which both citrate and acetate operate as intermediates has been recently summarized by Lehninger *(4)*. The general reactions involved in this area are as follows: decarboxylation of pyruvate to form an acetyl radical; condensation of the acetyl radical with coenzyme A to form "active acetate"; and condensation of active acetate with oxalacetate to form citrate. Since the Group B strains *(S. cremoris)* respond to acetate and not to citrate, it would appear that the decarboxylation of pyruvate may be the rate limiting reaction. This would not appear to be true of the Group A strains *(S. lactis)*. The Group A organisms responded to acetate but manifested a greater response to citrate. Pyruvate decarboxylation seems to be a factor with these organisms. Of the remaining reactions, the most likely site of a rate limiting reaction would appear to be the condensation of "active acetate" and oxalacetate to form citrate.

The dependence of *S. lactis* and *S. cremoris* upon pantothenate is in complete accord with the observations of Anderson and Elliker *(1)* and Niven *(5)*. The failure of coenzyme A to meet the pantothenate requirement of these organisms may be explainable on the basis of its molecular size and structure with respect to the cell membrane permeability.

SUMMARY

A study of the acetate-citrate metabolism of the lactic group of streptococci revealed that strains of *Streptococcus cremoris* responded significantly when a level of 10 mg. per milliliter of acetate was used in the medium but failed to respond when citrate was added at the same concentration; with some strains this level of citrate proved to be inhibitory. *Streptococcus lactis* responded significantly to this concentration of either acetate or citrate; the magnitude of the response to citrate was significantly greater than to acetate. These data support the contention that two distinct species exist in the lactic group of streptococci.

Experiments with calcium pantothenate revealed that all of the strains tested were unable to grow in its absence. Furthermore, coenzyme A as a source of pantothenate was considerably less effective in meeting this requirement than was Ca pantothenate.

REFERENCES

(1) ANDERSON, A. W., AND ELLIKER, P. R. The Nutritional Requirements of Lactic Streptococci Isolated from Starter Cultures. I. Growth in a Synthetic Medium. *J. Dairy Sci.*, **36**: 161. 1953.

(2) COLLINS, E. B., NELSON, F. E., AND PARMELLE, C. E. Acetate and Oleate Requirements of the Lactic Group of Streptococci. *J. Bacteriol.*, **59**: 69. 1950.

(3) HENDERSON, L. M., AND SNELL, E. E. A Uniform Medium for Determination of Amino Acids with Various Microorganisms. *J. Biol. Chem.*, **172**: 15. 1948.

(4) LEHNINGER, A. L. From Fats to Energy. *J. Agr. Food Chem.*, **1**: 1194. 1953.

(5) NIVEN, C. F., JR. Nutrition of *Streptococcus lactis*. *J. Bacteriol.*, **47**: 343. 1944.

PEOPLE and EVENTS
in the Dairy Science World

World Dairy Industry Point Four Program and Surplus Disposal Plan Launched by International Dairy Industry Group

A dynamic industry-spearheaded plan to insure an equitable and profitable distribution of the world's surplus dairy products to "have not" countries, and in turn enable the recipient countries to trade their own products for lifegiving and lifesaving milk foods, was made public recently by Dairy Industries Society, International.

Presented by GEORGE O. TIFFANY of Stamford, Conn., president of the world dairy group, the plan, calling for an industry Point IV program as well as a world surplus milk pool, both to be administered by the society or a nonprofit corporate subsidiary, was approved by the board of directors of the society at a meeting in Washington, D. C., on Dec. 17. Under this program, the society will set up two new entities, a World Dairy Foundation and a trading organization, World Milk Utilization, Inc. The foundation will have a research and development department and a technical assistance department to aid both governments and private industry, to establish extension services, and to conduct consumer educational and advertising tasks.

A Nonprofit Entity

World Milk Utilization, Inc., to be organized under the laws of one of the European dairy nations, probably Switzerland, will be a nonprofit commercial entity under the jurisdiction of the society (DISI), with its principal functions:

1) The maintenance of a permanent world surplus milk pool into which, upon reasonable terms and conditions, could flow the surplus milk products of all the dairy countries (being those amounts of milk products which are in excess of sales and distribution through all normal commercial channels) other than such quantities as are reserved for distribution in catastrophies and sudden emergencies; and out of which, under proper controls to circumvent black market dealing and smuggling, there could be drawn milk supplies for the economically underdeveloped areas of the earth only;

2) The maintenance of a permanent barter and exchange operation whereby it could be made conveniently possible, if not attractive, for the underdeveloped countries to obtain milk products for their underfed populations, not on a "give away" basis, but by direct purchases from the world surplus milk pool on terms and conditions fixed by good commercial practice, including negotiated prices and provision for payment either in hard currencies, such as dollars, pounds sterling, Swiss francs, etc., when available, or with their own soft currencies, if possible, or with raw materials, goods, wares, and merchandise produced by their nationals, when payment in either hard or their own soft currencies is not possible; and,

3) The maintenance of contractual arrangements with the government of the dairy countries, pursuant to which the latter would agree to purchase, at cost, all strategic and critical materials required by such governments for stockpiling under applicable laws of their respective countries and which are acquired by World Milk Utilization, Inc. in the course of its barter and exchange operations.

New Spoke to Point IV

In presenting his plan to the directors, Mr. Tiffany paid tribute to the work already done by the Point IV organizations—not only those of the various governments, but the United Nations organizations such as FAO, UNICEF, WHO, and UNESCO, and privately endowed foundations devoted to improvements in nutrition, agriculture, and health.

Asserting that give-away programs have obscured and often obliterated the real opportunities for economic advancement, through the dairy industry, in the nonmilk areas of the world, Mr. Tiffany said that people of these areas "do not want or appreciate our charity. Their sole and fervent hope is that, before it is too late and they are lost to communism, we will awaken to their real need and satisfy it. Their real need is to trade, and pay their own way with dignity befitting free human beings."

Outlines Surplus Pool Plan

In projecting the consequences of a corporate world milk utilization operation backed by private industry and drawing upon the skills and knowledge of dairy industry groups and individuals from all parts of the free world, Mr. Tiffany foresaw this activity :

1) "Providing a means for allowing the governments of the dairy countries grace-

fully to take themselves out of the business of disposing of their ever mounting, and sometimes politically embarrassing, stocks of surplus dairy products—a matter that has been exposed to lip-service unlimited, but about which little, if anything, has been done in actual practice;

2) "Providing a means for the smooth, nonpolitical and efficient carrying into effect of legislation aimed at accomplishing these very ends, such as Public Law 480 of the United States;

3) "Taking milk out of polities and off the lists of charity donations;

4) "Avoiding destructive price wars between the dairy countries waged with surplus dairy products as weapons and threatening to disrupt established commercial markets for normal supplies of dairy products;

5) "Avoiding the constant and depressing threat of 'dumping' of surplus dairy products on the world markets;

6) "Providing a means for enabling the peoples of the economically underdeveloped areas to trade and pay their own way with what they have to offer and with dignity befitting free human beings—the greatest single stimulant to economic development that exists; and,

7) "Getting milk's vital ingredients into the diets of the underfed populations of the earth—full bellies paid for by the sweat of their own brows, being the best deterrent to the encroachment of communism that the capitalistic system can offer to these less fortunate peoples."

Following the unanimous acceptance of the plan by the society's board of directors, two DISI spokesmen, IRVING C. REYNOLDS of Toledo, Ohio, and ROBERT ROSENBAUM of Philadelphia, who have also been active on the Dairy Export Advisory Committee of the Foreign Agricultural Service of the U. S. Department of Agriculture, discussed the program with the agricultural attaches of several of the dairy producing countries stationed in Washington and reported an enthusiastic preliminary interest.

Ralston Purina Announces Scholarships

The Ralston Purina Company has announced its research fellowship awards program for 1955-56, under which ten outstanding agricultural college students will be able to do graduate work. Application blanks and rules of the annual program are now being sent to agricultural colleges throughout the United States and Canada.

Selection of the ten winning students will be made, as in the past, by a committee of five, composed of a representative from the Poultry Science Assoc., the American Veterinary Medical Assoc., the American Dairy Science Assoc., the American Society of Animal Production, and the Assoc. of Land Grant Colleges. Three fellowships will be awarded in animal husbandry, three in dairy husbandry, three in poultry husbandry, and one in veterinary science. Each fellowship amounts to $1,560.

The purpose of the program is to help train outstanding college students for leadership in the science of livestock and poultry production. The first fellowships were granted for the 1949-50 school year. Among the 21 outstanding college students who have been chosen for the Purina Fellowship awards during the past five years, 15 are now staff members in colleges of agriculture, and one has become the head of his department.

Dairy Tech. at U. of I. to Hold Meetings

The Division of Dairy Technology of the Department of Food Technology of the Univ. of Illinois has scheduled the following meetings.

March 30-31,	Quality Control in Dairy Plants
April 12-14,	Bulk Handling of Milk
April 15,	Dairy Technology Career Day for High School Students
May 18-19,	New Uses for Milk Solids

In connection with the last conference, which will be held at the Univ. of Illinois in Chicago (Navy Pier), there will be a Dairy Products Fair on the afternoon and evening of the first day. The purpose of the fair is to show not only new and improved dairy products but also new uses of milk solids in allied food industries. The families of dairy plant workers, school children, and others interested in the educational aspects of the industry will be special guests.

News from Georgia

Seven freshmen majoring in dairying were awarded $200 scholarships for the year 1954-55 by individual dairy plants in the state. They were selected from the superior groups in their respective high schools on the basis of scholarship, extracurricular activities, and leadership ability. This group is the first of similar groups to be sponsored by commercial dairy plants in Georgia each year.

The Georgia 4-H Club Center at Rock Eagle Park near Eatonton, Ga., was dedicated Oct. 30, 1954. The first money for the project was raised by 4-H Club members. This was supplemented by many individuals, business organizations, and foundations. The center was completed when the state appropriated $1,000,000 to match funds provided by a Kellogg Foundation grant.

H. B. HENDERSON recently visited the following institutions on a study of dairy education in land-grant colleges sponsored by the Milk

Industry Foundation: Univ. of Tennessee, Univ. of Maryland, Rutgers Univ., Cornell Univ., Univ. of Connecticut, Ohio State Univ., and Purdue Univ. Other institutions are to be visited in the near future.

Did You Know That—

According to the Los Angeles County Farm Bureau Cow Testing Assoc., they have approximately 30,000 cows under test with the average production for the past year slightly over 480 lb. of milk fat. This they claim is the highest official production to be found anywhere.

There are approximately 100,000 milk cows in Los Angeles County.

The number of dairy cattle imported into Los Angeles County this year was 47,005, 40% of which came from Canada and 16 states other than California. Of these animals 0.259% were positive to the tuberculin test upon arrival.

There were 189 herds in Los Angeles County last year with 201 or more cattle. There were 29 herds with 501 or more cattle.

Zehren Joins Schreiber & Co.

V. L. ZEHREN, formerly a member of the Department of Dairy and Food Industries, Univ. of Wisconsin, has accepted a position as technical director with the L. D. Schreiber & Co., Inc., Green Bay, Wis.

U. of I. Makes Salary Survey of Graduates

The following table shows the range and pattern of employment undertaken by graduates of the College of Agriculture at the Univ. of Illinois as of the year 1950. The figures show a rather favorable situation of graduates in dairy products fields as compared with those in other lines of endeavor.

TABLE 1

Job distribution and salaries of agricultural graduates as of 1950

Job title	Graduates		Salary		Years since graduation				
	No.	% of total	No. reporting	Average salary	1-10	11-20	21-30	31-40	41-50
EDUCATIONAL WORKERS									
College teachers (total)	143	5.61	115	$5,918	46	29	37	29	2
Grad. assistants	22	.86	—	——	21	1	—	—	—
Instructors	17	.67	16	4,536	8	5	3	1	—
Assistant professors	30	1.18	27	4,922	11	9	8	2	—
Associate professors	21	.82	20	5,685	3	6	11	1	—
Professors	53	2.08	52	6,951	3	8	15	25	2
College administrators	9	.35	8	8,035	1	2	3	3	—
County agents (farm advisers)	92	3.61	89	5,345	22	33	21	16	—
Asst. county agents & youth advisers	49	1.92	49	3,520	47	2	—	—	—
Extension specialists & directors	29	1.14	29	5,666	6	7	8	8	—
High school teachers	431	16.92	391	4,356	233	81	87	30	—
Total educational workers	753	29.56	681	4,788	355	154	156	86	2
PROFESSIONAL TECHNICIANS									
Agronomists (total)	101	3.97	95	5,142	39	27	23	12	0
Soil conservation service	53	2.08	50	4,453	23	15	11	4	0
Soils	26	1.02	24	5,584	8	5	9	4	0
Crops	22	.86	21	6,278	8	7	3	4	0
Animal husbandmen	20	.79	16	4,938	14	4	2	0	0
Chemists and bacteriologists	24	.94	19	6,355	10	4	7	3	0
Dairy husbandmen	17	.67	16	4,010	12	4	0	1	0
Economists & statisticians	49	1.92	47	6,897	18	14	13	4	0
Engineers (agr. & others)	22	.86	19	5,096	8	4	5	5	0
Entomologists & zoologists	9	.35	8	5,980	0	2	6	0	1
Farmers home administration	23	.90	20	4,881	8	8	4	3	0
Horticulturists	10	.39	7	6,209	2	1	5	2	0
Inspectors (grain, seed, & feed)	18	.71	16	4,653	8	5	4	1	0
Total professional technicians	293	11.50	263	5,463	119	73	69	31	1
FARMERS AND FARM MANAGERS									
Farmers (total)	540	21.20	264	6,162	213	139	99	74	15
Owner-operators	195	7.66	71	7,787	18	30	72	61	14
Partnerships	143	5.61	81	5,450	90	38	12	3	0
Tenants	194	7.62	106	5,851	97	71	15	10	1
Farm hands	8	.31	6	2,033	8	0	0	0	0
Farm managers	113	4.44	96	5,000	49	34	16	10	4
Total farmers & farm managers	653	25.64	360	5,852	262	173	115	84	19

TABLE 1 (concluded)

Job distribution and salaries of agricultural graduates as of 1950

Job title	Graduates		Salary		Years since graduation				
	No.	% of total	No. reporting	Average salary	1-10	11-20	21-30	31-40	41-50
BUSINESS & INDUSTRY									
Managers and supervisors	233	9.15	208	8,148	73	75	58	24	3
Agriculture cooperatives	18	.71	18	6,207	8	4	5	1	0
Dairy manufactures	65	2.55	57	8,529	19	26	15	5	0
Fruits, vegetables, & produce	17	.67	13	6,336	8	4	1	4	0
Grain, seed, feed, fertilizer	50	1.96	45	9,288	14	15	16	4	1
Hatcheries	11	.43	7	6,641	3	6	1	1	0
Livestock marketing & meat packing	16	.63	16	4,108	7	2	4	2	1
Machinery, equipment, & service	53	2.08	49	8,629	14	17	15	6	1
Miscellaneous business & service	3	.12	3	20,500	0	1	1	1	0
Salesmen & sales managers	176	6.91	153	6,378	84	38	31	19	4
Agricultural chemicals	8	.31	8	6,388	5	3	0	0	0
Dairy products	16	.63	14	6,700	8	7	1	0	0
Feed	18	.71	16	5,351	12	3	2	1	0
Fertilizer	20	.79	18	4,703	12	4	3	1	0
Grain, grain products, & seed	20	.79	19	6,169	8	5	5	1	1
Insurance	48	1.88	36	7,510	24	8	6	8	2
Livestock products (meat, eggs)	8	.31	8	4,510	8	0	0	0	0
Machinery & equipment	21	.82	18	7,683	5	5	6	4	1
Miscellaneous products & equipment	17	.67	16	6,164	2	3	8	4	0
Owners & operators, miscellaneous									
Non-agricultural businesses	31	1.22	23	12,470	3	6	6	15	1
Florists, nursery, & landscaping	82	3.22	58	7,488	16	30	20	15	1
Farm loans & appraisal	47	1.85	47	5,773	8	21	7	11	0
Bank officials	16	.63	15	9,685	2	3	6	5	0
Real estate & loan agents	11	.43	8	9,512	1	0	6	4	0
Journalism, radio & advertising	37	1.45	29	8,570	11	8	10	8	0
Public relations	9	.35	9	8,581	2	2	4	0	1
Laboratory technicians	8	.31	8	2,981	7	0	1	0	0
Total business & industry	650	25.52	558	7,588	207	183	149	101	10
MISCELLANEOUS PROFESSIONS & OTHERS									
Doctors & dentists	11	.43	—	——	1	3	3	3	1
Veterinarians	5	.20	—	——	5	0	0	0	0
Lawyers	11	.43	—	——	7	1	2	1	0
Ministers & missionaries	11	.43	7	4,200	3	1	5	2	0
Public officials (government)	42	1.65	35	5,989	7	5	18	11	1
Army, navy, and air force	22	.86	19	6,009	9	10	2	1	0
Students (graduate & professional)	46	1.81	—	——	42	2	2	0	0
Retired & disabled	26	1.02	—	——	2	0	3	19	2
General miscellaneous	24	.94	18	4,362	10	6	5	3	0
Totals	198	7.77	79	5,465	85	28	40	40	4
GRAND TOTAL	2,547	99.99	1,941	$5,909	1,029	611	529	342	36

V.P.I. Dairy News

W. K. STONE became a member of the staff of the Department of Dairy Husbandry at Virginia Polytechnic Institute on Dec. 1, 1954. He will devote full time to dairy manufacture research. Dr. Stone received his B.S. and M.S. degrees from Utah Agricultural College and his Ph.D. degree from Wisconsin.

T. M. COMBS completed the requirements for a Master's degree in December, 1954, and has accepted a position with the Carnation Milk Co., Danville, Ky.

R. G. CONNELLY is on a year's leave of absence as extension dairyman to organize and promote the Virginia Milk Producers Federation and to serve as executive secretary of the Virginia State Dairymen's Assoc. His principal duties consist of setting up an organized program for the sale of milk and the education of the consumer of milk and dairy products.

The Department of Dairy Husbandry will offer the following short courses and conferences: Dairy Herd Management Short Course, Jan. 10-13, 1955; Quality Milk Conference and

Clinic, Feb. 16-17; Ice Cream Manufacture Conference and Clinic, March 2 & 3; Cottage Cheese and Buttermilk Manufacture Conference and Clinic, March 16 & 17.

Harshbarger on Cornell Campus

K. E. HARSHBARGER, assistant professor of dairy production at the University of Illinois, is spending the year at Cornell University where he is teaching the beginning course in dairy cattle.

Dairy Shrine Elects Officers

FLOYD JOHNSTON, secretary of the American Jersey Cattle Club, was elected president of the Dairy Shrine at the time of its recent meeting held at Waterloo, Iowa. Other officers included GEORGE BULLSEY of the Carnation Co., vice-president, and JOE EVES, secretary-treasurer. Mr. Eves also was named Guest of Honor, and his portrait was hung in the halls of the club.

Teaching Techniques Submitted by Teachers

Use a student as the person in an hypothesis—on occasion.
Call all students by first name.
Strike hard at the sleepy or lazy student.
Express an unreasonable opinion and pause for reaction.
A minimum of one joke per class related to the subject matter.
Pass examples of the subject matter around the room when possible.
Refer to current events frequently, drawing from local newspapers.
Relate subject matter to probable situations in home towns.
Suggest how a point may be used in future professions.
Bring in farmers' letters that contain problems or questions.
Use good visual aids.
Relax the police control.
Be prepared to meet the class.
Invite criticisms from the class.

Burgwald Takes Year's Leave

L. H. BURGWALD, Department of Dairy Technology, The Ohio State University, has been granted a year's leave of absence to visit foreign countries as a consultant marketing specialist. He will be traveling under the supervision of the Market Development, Livestock and Livestock Products Division, Foreign Marketing Branch of the Foreign Agriculture Service, USDA. His main objective will be to make a survey of foreign countries regarding marketing possibilities for our surplus dairy products. His first assignment will be in India.

Edward K. Slater Dies

EDWARD K. SLATER, who for many years was editor-in-chief of the Olsen Publishing Co., died in California on December 17 at the age of 77. A veteran of the Spanish American War, he was at one time a member of the dairy staff at the Univ. of Minnesota. He was active in a large number of dairy organizations and was connected with the Olsen Publishing Co. from 1920 to 1952.

Kentucky News

R. J. WILSON has been appointed manager of American Dairy Assoc. of Kentucky, with headquarters in Louisville. Mr. Wilson went to Kentucky from Green Bay, Wis., where for 4 years he was district manager for A.D.A. Prior to this he was employed in the merchandising department of Kraft Foods Co.

On Dec. 2 the third annual dairy faculty-student mixer was held in the Livestock Judging Pavilion. This get-acquainted affair is sponsored each year by the staff members of the Dairy Section.

E. N. BOYD, assistant professor of dairying and superintendent of the creamery, has resigned to accept an appointment on the research staff of Swift and Company, Chicago, effective Feb. 1, 1955. Dr. Boyd has been a member of the U. K. dairy staff since July, 1952.

"Milk for Health of Louisville" will sponsor an extensive, organized cottage cheese promotional program during the Lenten season. R. J. WERNER of the Milk Industry Foundation will be in Louisville to give his personal supervision to this merchandising campaign. Staff members of the U.K. Dairy Section are giving assistance in the quality improvement and control phase of the program. It is the plan of "Milk for Health of Louisville" that this intensive Lenten season effort will serve as a spearhead for a stepped-up cottage cheese program throughout the year.

Completed Theses

M.S. Degree:

S. M. DIAMOND—The Modified Richardson Biochemical Pregnancy Test as applied to dairy cattle. Univ. of Georgia.

J. C. MAHAFFEY—The effects of certain factors on the diurnal excretion pattern of chromic oxide. Univ. of Georgia.

T. M. COMBS—A study of the solids-not-fat content of individual cow's milk. Virginia Poly. Institute.

Ph.D. Degree:

KENNETH A. TABLER—Selection indices based on milk and fat yield, fat per cent, and type classification of dairy cattle. Univ. of Illinois.

The Need for Dairy Research

A Guest Editorial

Today's frontiers lie in the application of technology. To a large extent the ingenuity of man is being applied to the creation of products and devices that compete with those which have been used by man for centuries. The products of yesterday usually were gifts of nature which required little refining or processing to make them useful. Then, the best suits were made from wool; today, excellent suits are available that literally are made from air. Chemical technology has taken nitrogen and oxygen from the air and methane from the earth's fermentation and converted them into new fabrics. The ingenuity of man is finding new, and often more economical, ways of converting the chemical elements into useful products.

Mark Keeney

The dairy industry is feeling the effect of technological production of substitute products. Milk fat is getting strong competition from new fats produced as the result of technological advances in the fat rendering industry. It seems reasonable to predict that the same technology which produced suits from air will eventually produce amino acids or protein-like substances from the atmosphere. Intensive research is now being directed at the production of new sources of cheap protein from plants and microorganisms. The recognition of vitamins as essential parts of our foods during the first half of this century was followed by their commercial synthesis from relatively inexpensive materials. These developments presage vigorous competition for the dairy industry in the food market of the future.

Strong action must be taken by the dairy industry if it is to prosper in this market. Many suggestions have been advanced as to the type of action needed. These include: more efficient milk production, better distribution methods, development of new milk products, more aggressive selling and advertising, and quality improvement. What must be done before these suggestions can be put into effective action?

First of all, the facts bearing on a particular problem must be collected and evaluated by those responsible for making decisions. The facts are discovered and made available by the research worker. The fundamental source of progressive action is research. Management must have the facts uncovered by research before it can make wise business decisions. At the present time there are not enough available facts to allow effective action to be taken on some of the suggestions. The dairy industry has not supported and conducted enough research to make the needed facts available. It is commonly recognized that the industries which are providing competition for dairy products, such as the manufacturers of substitute fats, place a great deal of value on research. It has been estimated that such companies invest from 2 to 3% of their sales in research, while the dairy industry invests approximately 0.1% of sales in research. It is no mere accident that the most prosperous and fastest growing industries in this technological age are the ones which place a high value on research. Research is the sire of technology, and these industries know it.

With the exception of the money spent on research by a few progressive dairy companies, most of the funds for dairy research come from general taxes. This public research in the U. S. Department of Agriculture and the state experiment stations is not enough to provide the facts needed by the dairy industry. It is evident that any significant increase in dairy research will have to be supported by the dairy industry itself. Dairy farmers have a vital and direct interest in research because their future will be governed by how well research uncovers the facts necessary to solve the technical and economic problems of getting milk from the cow into the human stomach. The manufacturing section of the industry is obviously concerned with research in conducting this job.

Suppose each dairy farmer in the United States were to invest one dime per month in research for each of his milk cows. The total of these dimes would be about 25 million dollars per year. Also suppose that the manufacturing section of the industry were to match this amount. Fifty million dollars may seem like a lot of money for research. The Department of Agriculture spends only about one and one-half million dollars per year on dairy research. No state experiment station or private dairy company spends as much as the Department of Agriculture on dairy research.

Milk has enough inherent and unique value that it will be used as food by man as far into the future as we care to look. However, there will be constant attrition on the dairy industry from competitive foods developed by technology. The dairy industry can compete with these new foods and even grow more prosperous than it is today, provided millions, and not thousands, are spent on research to develop the potentialities of milk—that wonderful gift of nature.

MARK KEENEY
Dairy Husbandry Department
University of Maryland

OUR INDUSTRY TODAY

Brief Reviews of Current Topics

A System of Continuous Buttermaking[1]

A. H. Rishoi

Research Department, Cherry-Burrell Corporation, Chicago

There are now 27 "lines" or 2,000 lb. per hour units of the continuous system in operation in the United States, Canada, and Mexico. The importance of these units so far as total butter production is concerned can be gauged by the fact that during the past 5 or 6 years about a quarter of a billion pounds of continuously made butter has passed through normal trade channels to consumers. The experience obtained in the processing of substantial quantities of butter and the knowledge gained as to consumer acceptance seem to warrant the belief that this system of production has a permanent place in the industry.

Historical Aspects

The continuous system had its beginning in some experiments conducted at the Sugar Creek Creamery, Danville, Ill., in 1939. Early in 1941 an agreement was entered into between the Sugar Creek Creamery and the Cherry-Burrell Corporation of Chicago, for the cooperative development of a system of continuous buttermaking.

The principal steps in the process as originally conceived were as follows: (1) Heating cream to about 120° F. for separation, (2) separating the cream to 85-90% fat concentrate with a standard centrifugal separator, (3) pasteurizing the fat concentrate, (4) standardizing the fat concentrate to the composition desired for butter, (5) chilling and working the product continuously, using a modified Vogt ice cream freezer—exit temperature 40-45° F., and (6) boxing the butter or storing unpackaged cubes for later printing.

It was evident from the start that, although the principal steps were logical and practical, a series of refinements, changes, and improvements would be necessary if the system of production was to be profitable to the industry and its product acceptable to the consumer.

Special Separator Developed

For reasons of operation, 88-92% fat in the concentrate was desired, and, for reasons of economy, a preliminary goal of 1% fat loss during separation was adopted. During the early stages of the development of the system, sour cream only was available, and the problem then became that of separating sour cream to the desired concentration and exhaustiveness and maintaining conditions permitting continuous operation. Since a standard centrifugal cream separator was found to be unsuited for this purpose, an industrial centrifugal separator was tried and after some modifications adopted.

The cream entering the separator is discharged as three separate products. That discharged from the regular skimmilk outlet is called "light skimmilk." Light skimmilk from sour cream is much like whey. Secondly, the product discharged from the ports in the bowl periphery is called "heavy skimmilk." It contains most of the casein precipitated in sour cream. When separating sweet cream, light skimmilk and heavy skimmilk are identical in composition. Finally, the fat concentrate is discharged from the regular cream outlet.

The separation of sour cream presented the first obstacle to be overcome. The centrifugal force resulting from the rotating separator bowl caused the precipitated curd in the cream to be deposited in the annular space between the disc stack and the bowl, also between the discs. After a few minutes operation these spaces would be filled with curd, resulting in loss of separating efficiency both as to exhaustiveness and degree of concentration. Even a slight degree of acidity in the cream, titration values of 0.25-0.30%, produced this condition. A remedy for this deposition of curd in the separator bowl was found by placing two inserts, with holes about 0.030 in. diameter, in the separator shell wall.

Through these holes about 800-1,000 lb. of heavy skimmilk was discharged per hour. This heavy skimmilk contained most of the precipitated curd. Some curd was deposited along the bowl shell between the discharge ports, but after a few minutes operation a maximum was reached, and efficient operation continued for a full work day. Modifications of these peripheral discharge ports have been made but their principle and function remain unchanged.

Even though the peripheral discharge ports permitted uninterrupted operation of the separators, the amount of the total fat lost in the

[1] The continuous process of buttermaking referred to throughout this discussion applies only to the Cherry-Burrell Gold'n Flow system.

light and the heavy skimmilk remained too high, usually around 2%.

Microscopic examination showed that when the acidity of the heavy skimmilk was reduced to about neutral, large numbers of fat globules were liberated from the curd. Standardization of the cream acidity changed the casein to a viscous, gummy product, which was not discharged from the separator through either the light or the heavy skimmilk ports. Standardization of cream acidity was not the remedy for excessive fat losses during separation.

Separator construction further improved. The separation of cream was improved to its present efficiency by the adoption of two expedients: (1) opening discharge channels between the primary separating chamber and the annular space between the disc stacks and the bowl shell, and (2) improving the facilities for the practice termed "destabilizing" the cream.

The discharge channels between the primary separating chamber and the outer annular space serve two purposes. First, they permit the curd to pass through these channels directly to the outer annular space, thus by-passing the discs. Secondly, the reduction in volume of product to pass through the discs permits such free fat as may be present to separate in the chamber and pass immediately through the regular channels directly to the cream outlet. These two extra exits, one for heavy skimmilk and one for fat, increase the separating efficiency of the discs by increasing the time the cream is subjected to centrifugation. The word "destabilization" is used to describe the procedure and results obtained when cooled cream is pumped through a device resembling a centrifugal pump operating at high speed and equipped with perforated impellers. An air valve on the inlet side of the destabilizing unit permits air to be incorporated in the cream emulsion. A product similar to whipped cream is produced; fat globules collect and to a degree coalesce on the air-liquid interface; the original cream emulsion is weakened and becomes destabilized. Under some circumstances the emulsion may even be reversed. Since the capacity of the working chamber is about 1 lb. of cream, the destabilizing step is of less than 1-second duration when operating at 4,000 lb. an hour. When destabilized cream is heated and separated two advantages are gained. The efficiency of separation is increased, and the fat content of the concentrate is raised to 88-92%.

Fat losses low. Under conditions of normal operation, the fat content of the light skimmilk may be in the 0.15-0.25% range, whereas that of the heavy skimmilk may be in the 0.5-0.75% range. If it is assumed that cream containing 35% fat is separated and that the light skimmilk and the heavy skimmilk contain 0.20% and 0.60% fat, respectively, the total losses would be about 0.57% of the total fat.

In volume the heavy skimmilk is little more than half that of the light skimmilk discharged, yet it contains 50-65% of the total fat lost during separation. Various postulates may be used to explain the reason for this, such as imprisonment of fat globules by agglutination of curd particles by acid or heat, rolling up of casein, or perhaps just adhesion to the curd particles. When sweet cream is being processed, the light and the heavy skimmilk fat tests are identical.

A considerable number of records show that the losses sustained during separation of sweet cream are below those experienced with sour cream. Separation losses for sweet cream are usually in the range of 0.45-0.60% of the total fat. The quantity of skimmilk and the percentage of total fat lost during separation are in inverse relation to the richness of the cream being processed. For this reason, it is advantageous to process cream with a fat content of 40%, or higher.

Table 1 shows the procedure followed in calculating fat losses during skimming of sour cream. Also, representative data are shown regarding the extent of these losses.

The values shown in Table 1 were taken from actual performance data and represent normal operations for sour cream. When compared with similar representative losses for the conventional churn system these data illustrate the greater efficiency of the continuous system over the conventional batch method. The average of the values presented in Table 1 is 0.78%. Data regarding fat lost in the buttermilk during conventional churning indicate values around 1.1-1.25%. Some variation above or below the values given for each system may be expected, but the general relationship is representative.

The procedure for calculating total fat lost during separation is as follows:

Lb. of light skimmilk obtained per hour = 1
Lb. of heavy skimmilk obtained per hour = 2
Lb. of concentrate obtained per hour = 3
Total fat processed per hour = 1 + 2 + 3

$$\text{Per cent total fat lost} = \frac{1 + 2}{1 + 2 + 3} \times 100$$

Control of composition. A second factor determining the efficiency of operation is the composition of the finished product. The concentrate delivered by the separator has a composition approximately as follows: fat, 90%; water and solids-not-fat, 10%. The curd content of the concentrate is about 1% for sweet cream and 0.5-0.75% for sour cream. Before being chilled, the concentrate is standardized to the fat content desired for the finished butter, usually 80.2%. A recheck for accuracy of composition should be made before it is released for chilling. Thousands of analyses show that a remarkable degree of composition control can be maintained. A majority of samples will be found in the range of 80.1-80.2% fat.

Illustrative of the uniformity of fat content

TABLE 1

Data from records of separator performance under routine operating conditions of the continuous buttermaking system (Nebraska)

Date	Cream separated	Fat concentrate			Light skimmilk			Heavy skimmilk			Fat separated		
	(lb/hr)	*(lb/hr)*	*(% fat)*	*(lb. fat)*	*(lb/hr)*	*(% fat)*	*(lb. fat)*	*(lb/hr)*	*(% fat)*	*(lb. fat)*	*(total lb.)*	*(lb. lost)*	*(% loss)*
5/28/52	2,595	975	91.1	888	840	0.20	1.68	780	0.8	6.24	896	7.84	0.89
"	2,925	1,110	90.9	1,009	1,035	0.26	2.69	780	0.8	6.24	1,018	8.93	0.88
"	3,630	1,335	90.2	1,205	1,470	0.22	3.23	825	1.0	8.25	1,216	11.48	0.94
"	3,645	1,350	90.1	1,216	1,470	0.22	3.23	825	1.0	8.25	1,227	11.48	0.93
"	3,675	1,470	87.8	1,291	1,425	0.16	2.28	780	0.8	6.24	1,300	8.52	0.65
"	3,750	1,530	87.2	1,334	1,440	0.24	3.46	780	0.8	6.24	1,344	9.70	0.72
"	3,360	1,320	90.8	1,198	1,260	0.22	2.77	780	1.2	9.36	1,210	12.13	1.00
"	3,420	1,365	89.4	1,220	1,275	0.19	2.42	780	1.0	7.80	1,230	10.22	0.83
"	3,390	1,335	92.3	1,232	1,275	0.26	3.31	780	0.6	4.68	1,240	7.99	0.64
"	3,645	1,455	89.3	1,299	1,380	0.28	3.86	810	0.8	6.48	1,309	10.34	0.79
4/14/52	4,560	1,680	88.0	1,478	2,040	0.28	5.71	840	0.8	6.72	1,490.5	12.43	0.83
"	4,590	1,680	87.8	1,475	2,070	0.35	7.25	840	0.8	6.72	1,489	13.97	0.94
"	4,755	1,935	88.0	1,702	1,980	0.36	7.13	840	0.9	7.56	1,716.7	14.69	0.86
"	4,650	1,860	88.1	1,639	1,950	0.42	8.19	840	0.8	6.72	1,654	14.91	0.90
"	4,620	1,770	87.0	1,540	2,010	0.20	4.02	840	0.5	4.20	1,548	8.22	0.54
"	4,485	1,695	87.9	1,490	1,950	0.36	7.02	840	0.5	4.20	1,501	11.22	0.75
"	4,125	1,560	89.3	1,393	1,725	0.32	5.74	840	0.6	5.04	1,404	10.78	0.77
"	4,410	1,680	89.2	1,499	1,890	0.39	7.37	840	0.6	5.04	1,511	12.41	0.82
"	4,230	1,590	89.1	1,417	1,800	0.30	5.40	840	0.8	6.72	1,429	12.12	0.85
"	4,245	1,590	89.0	1,415	1,815	0.32	5.80	840	0.7	5.88	1,426	11.68	0.82

attained in the butter is a report of 129 consecutive lots in which the highest fat content was 80.5% (one lot) and the lowest was 80.0%. The average for the lots was just below 80.1%. It should be recognized that such efficiency is reached only when full cooperation exists between all concerned in the operation.

Pasteurization. In all installations of this system, the "Vacreator" is used for pasteurizing the 90% fat concentrate. Several investigators have shown this machine to be fully adequate to do the job of pasteurization and in addition to have the virtue of removing possible unwanted flavors from the product. The pasteurization temperature is usually maintained at or above 200° F. and is done immediately after separation.

The chiller-worker. The original chiller-worker used in this development was a standard single-tube Vogt continuous ice cream freezer. Because of the well established standards of

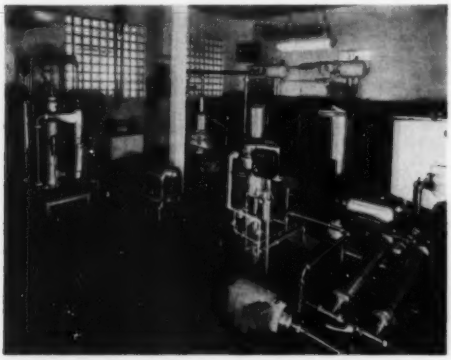

FIG. 1. A continuous system for making butter. The cream is pumped from the storage tank, shown on the right, and then passes successively through the destabilizing pump, the centrifugal heater, the centrifugal separator, the Vacreator, and finally to the round composition control tanks shown in the rear of the photograph.

body and texture of butter, it was necessary to adapt the freezer to produce butter conforming to the required physical characteristics of this product. In this connection, the r.p.m. of the mutator, the pressure under which the product was made, the temperature of the ammonia refrigerant, temperature of product, and duration and intensity of chilling and working were all factors to be studied and correlated.

Finally, the behavior of the butter after being discharged from the chiller presented a series of problems. Because of a distinct rise in temperature, it was evident that a state of physical equilibrium had not been reached at the point of discharge of the butter from the chiller. In order to minimize such consequent objectionable features as excessive hardness and brittleness, a tube was interposed between

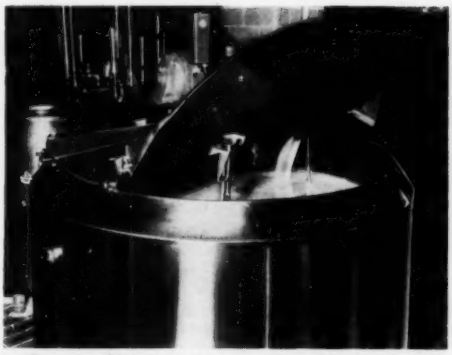

FIG. 2. Showing the fat concentrate entering a composition control tank.

the chiller discharge and the final discharge for packaging. This tube is called a "Texturator." It functions as a holding or delaying section, permitting crystallization of the fat to continue for a period of time. Then as the butter approaches final discharge it passes through cone-shaped perforations in a disc within the Texturator. Passage through the cone produces a shearing action on the butter, and such crystal structures or meshes as may have been started are to a large degree destroyed. This destruction of mesh or structure bestows on the butter the soft, spreadable characteristic demanded by consumers. A minor degree of crystallization continues after the butter is discharged from the Texturator. The chiller-worker operates at a capacity of about 2,000 lb. of butter per hour.

Present Procedure

The present procedure of manufacture is as follows: As the first step, the cream is pumped through a strainer to the destabilizing unit. The cream should be in the temperature range of 65-75° F. After destabilization, the cream goes directly to the centrifugal heater, where its temperature is raised to 125-150° F. The

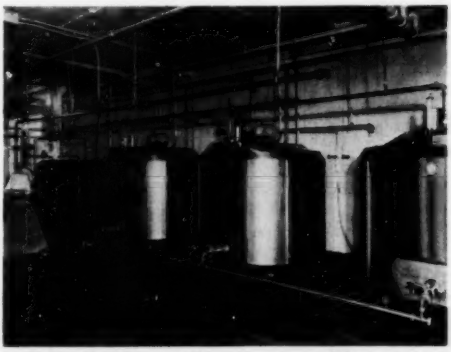

FIG. 3. Three 600-gal. composition control tanks. C. A. Swanson and Son, Omaha, Neb.

cream then goes to the centrifugal separator. The light and heavy skimmilk is piped away, and the fat concentrate is pumped to the Vacreator for pasteurization. The pasteurized concentrate is collected in special 300- or 600-gal. stainless steel composition control tanks, where it is standardized to the desired composition and, if necessary, acidity. The concentrate is then chilled and worked in a two-tube chiller and finally discharged from the Texturator as butter. As it emerges from the Texturator at 40-45° F., the butter may be printed at once or stored in bulk or in packages as desired.

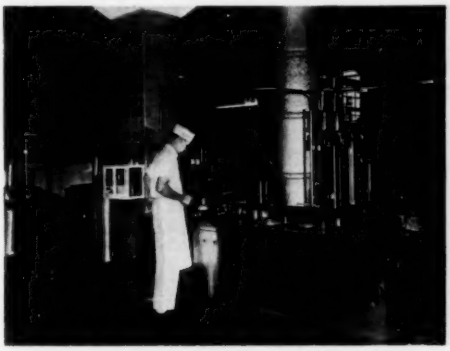

FIG. 4. Laboratory desk in the processing room in Pickerington, Ohio.

General advantages. Economy of operation involves such items as depreciation of machinery, refrigeration requirements, fuel, water, and steam consumption and, of course, labor cost. Very few data are available on these items. They are difficult to gather and are usually held confidential by operators. Sufficient information, however, has been made available to show that the over-all cost of production by this system is below that incurred in making butter by the conventional batch method. The savings vary from 15-40%.

It must not be assumed that all the advantages of the system are as great or as obvious as those already mentioned. The dividing line between major and minor advantages is not a sharp one and their significance may vary with the interests of the individual. For example, the continuous process has certain desirable sanitary features. Aside from the highly efficient pasteurization provided there is a minimum of opportunity for subsequent contamination during standardization, chilling, and packaging.

Operators interested in flavor will appreciate the fact that the product, from cream to finished butter, contacts only stainless steel. Persons interested in the consistency of butter will appreciate the fine texture and body of the product and its uniform composition. Plant managers will recognize the advantages of greatly reduced space requirements for operations. In some plants the reduction in space necessary for operating the system has been from 30 to 50% as compared with the conventional batch system. Finally, a very important item in favor of this continuous system is that much less hard manual work is involved than is required in the conventional batch system.

FIG. 5. Processing room at Frank Pilley and Sons Creamery, Sioux City, Iowa, showing four 600-gal. composition control tanks and two chillers.

In practice the continuous system is simple, but it would be erroneous to think of it as a "push button" operation. Operators must have a fundamental knowledge of butter and buttermaking and be able to adapt this knowledge to somewhat variable conditions. In addition, they should have some aptitude for operating machines. They must be aware that in a system of continuous operation, in which the performance of a dozen or more machines and as many processes must be coordinated for satisfactory results, one failure stops the entire operation.

From the foregoing description, it is obvious that a method of continuous buttermaking is suitable only for creameries manufacturing relatively large quantities of butter. For the system to be profitable for an operator, a minimum production of one million pounds annually has been suggested.

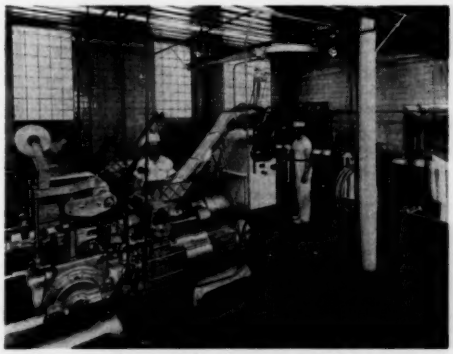

FIG. 6. Three 300-gallon composition control tanks and chiller. The butter is being printed direct from the Texturator discharge.

What Producers are Doing to Conform Milk Production to the Needs of the Chicago Market

J. H. ARGUE
Pure Milk Association, Chicago

In order to clearly understand the problems facing the market and the possible means of solution, it would be well to first examine the basis of pricing under the Federal Order, without going into all the details and ramifications. Simply, the order provides for prices to producers on a use basis. Although there are several specific classes of milk, depending not on quality but on use, these classes can be segregated into two general categories.

First, there are the milk and cream in fluid uses, requiring by ordinance a Grade A supply, which commands a higher price than milk used for manufacturing. This higher price, in the Chicago market, is related to and based on the price for manufacturing milk. This is the only portion of the milk for which the producer receives additional payment for producing Grade A milk.

Secondly, there is the milk used for nonfluid or manufacturing purposes, which is priced at the level of non-Grade A milk used for butter, milk powder, cheese, and evaporated milk. For this portion of the milk no additional payment is made for the production of Grade A milk.

There is assumed agreement that milk used for bottling (fluid) uses should receive a higher price than that for manufacturing. It is not necessary here to concern ourselves with the amount of additional price paid.

Under the market wide pool operation, all producers whose milk is priced under the order receive a weighted average of the several prices outlined above. Although prices were higher in the short production season than in the flush season, an individual producer's pattern of production seasonally had little effect on his price, since it was blended with that of over 23,000 other producers.

The Problem

Production on farms supplying the Chicago area market was found to be almost 150 lb. in May and June for each 100 lb. produced in October and November. This gives a seasonality index of about 150.

The calculated seasonality index for the past several years is as shown in Table 1.

This table shows that while there has been variation, there has been little improvement during this period. Therefore, it can be concluded that the present price structure was preventing wider seasonality but was not reducing it.

Since fluid sales are somewhat level throughout the year, only the equivalent of minimum production could be considered eligible or accessible for fluid sales. Substantially all production in excess of the minimum of necessity must be utilized for low-price manufacturing or surplus purposes.

TABLE 1

Comparison of maximum and minimum average daily deliveries of producer milk Chicago Market, 1946 thru 1954

Year	Average daily delivery per producer: Maximum month	Average daily delivery per producer: Preceding & succeeding minimum month (Av.)	Index number of maximum month (minimum month-100)
	(lb.)	*(lb.)*	
1946	494	324.5	152
1947	498	320.5	155
1948	503	325.5	155
1949	538	341.5	158
1950	531	350.5	162
1951	553	350.5	168
1952	570	361.0	158
1953	608	398.0	153
1954	638	428.0[a]	148

[a] 1954 minimum month estimated.

During the 1946 thru 1954 period, surplus milk in the Chicago market increased. This increase was not due to changing seasonality but largely to general production increases which also were occurring on a nationwide basis.

The extent of these increases was as follows:

TABLE 2

Average monthly production, fluid sales, surplus, and rates of surplus to production Chicago market, 1946 thru 1954

Year	Total production	Fluid sales Class I & II	Surplus Class III & IV	Ratio surplus to production
	(mill. lb.)	*(mill. lb.)*	*(mill. lb.)*	*(%)*
1946	243.4	226.2	17.2	7.1
1947	259.4	220.7	38.7	14.9
1948	268.7	221.5	47.2	17.6
1949	302.8	221.1	81.7	27.0
1950	315.6	226.2	89.4	28.3
1951	306.6	234.0	72.6	23.7
1952	315.9	231.9	84.0	26.6
1953	364.3	230.3	134.0	36.8
1954[a]	385.4	242.1	143.3	37.2

[a] Last three months estimated.

It should be noted that any decreases in fluid sales were due entirely to reduction in cream sales, bottled milk, or ice cream. Sales of bottled milk showed a steady increase from 139 million pounds per month in 1946 to 180 million pounds per month in 1954. To get some idea of the magnitude of these figures, the Chicago market total production represents over 3½% of total milk production in the United States.

The surplus shown in Table 2, if manufactured entirely into the various products, would yield approximately the following per year:

Butter	73 million pounds
Nonfat dry milk solids	141 million pounds
Cheddar cheese	162 million pounds

There is more involved than prices paid to producers. The additional problem caused by seasonality of production is the uneven load placed on manufacturing facilities. Surplus handling plants must process much of this surplus during just a few months of the year and, of necessity, stand partially or wholly idle during several months of each year. Idle facilities and stand-by personnel are costly. It has been indicated that the stand-by cost for unused plants and labor is about 18¢ per cwt. of unused capacity for butter powder plants. This figure is derived from testimony presented at various Order 41 (Chicago) hearings.

Applying these stand-by costs to the surplus carried in the Chicago market provides the data for Table 3.

This table shows that facilities were required to manufacture a maximum of 7.81 million pounds of milk daily, whereas only 4.78 million pounds were manufactured per day on an average. The stand-by facilities with a capacity of 3.03 million pounds daily required an estimated investment of 6.06 million dollars. The cost of stand-by facilities and labor necessitated by seasonal production amounted to almost 2 million dollars for the year, or 4.2¢ per cwt. on the entire production for the market.

It would appear that this cost is ultimately borne by producers, since they receive the residual of what consumers pay for their product after all costs, including surplus handling, are deducted.

Producers Attack the Problem

Major producer groups in the market analyzed the problem and felt there was much to be gained from more level production. Even without reducing the annual surplus, level production would reduce the costs of handling surplus; would provide the basis for a better marketing program for both fluid milk and manufactured products; would recognize that the pattern of production of fluid milk which cannot be stored for later use should more nearly conform to needs of the market for which it was intended; and would ultimately result in reduced costs of handling from producers to consumer and in relatively better returns to the producers who are willing to reduce the seasonality of their production.

A concrete plan has been more difficult to formulate for the Chicago market because of the large quantity of milk involved and the tremendous area which comprises the Chicago milk shed. However, it was noted that several large markets were using plans successfully, such as Detroit, where the seasonality index was only 120, and Milwaukee, where it was only 127.

After study, a plan of pricing to provide incentive to the individual producer to level production was completed and proposed for inclusion in Federal Order No. 41. It was proposed that it be added to the seasonal pricing features of the present order to insure that any effects would be over and above those already operating in the price system for the market.

TABLE 3

Cost of unused manufacturing facilities resulting from seasonal production Chicago market, 1946 thru 1954

Year	Surplus milk		Average unused capacity per day	Investment in unused facilities	Stand-by cost of unused facilities	
	Maximum per day	Average per day			Per year	Per cwt.
	(million lb.)	*(million lb.)*	*(million lb.)*	*(million $)*	*(thousand $)*	*(cents)*
1946	1.00	0.57	0.43	0.86	282.5	1.0
1947	2.41	1.29	1.12	2.24	735.8	2.3
1948	2.30	1.57	0.73	1.46	479.6	1.5
1949	4.58	2.72	1.86	3.72	1,222.0	3.3
1950	4.64	2.98	1.66	3.32	1,090.6	2.8
1951	4.26	2.42	1.84	3.68	1,208.9	3.2
1952	4.76	2.80	1.96	3.92	1,287.7	3.4
1953	7.01	4.47	2.54	5.08	1,668.8	3.8
1954[a]	7.81	4.78	3.03	6.06	1,990.7	4.2

[a] Last three months estimated.

The Level Production Plan

The plan was proposed at a hearing in June and became a part of the Federal Order as of September 1, 1954. The essential parts of the plan are as follows:

(a) During September, October, and November of each year, each producer will establish a base equal to his average daily deliveries during these months.

(b) If he does not deliver during this period, or desires to abandon his earned base, the producer will be assigned a base, computed on a percentage basis roughly 10 percentage points less than the average of those earning bases.

(c) In the months of March, April, May, and June of each year, a relatively high price will be paid for the equivalent of the base milk (fall production) and a lower price for production in excess of the base. These two prices will be so calculated that the price for the base milk is 40¢ per cwt. above the price for excess milk.

(d) The single average price to producers will continue to be paid during the other eight months of July through February.

Effects of the Plan

The immediate effects of the plan will be as follows:

(a) Whereas previously the effect of the single average price plan was to pay all producers as if their seasonality were the same, the new plan will pay more money to those with production which is more level and less to those with high seasonality.

(b) The plan will not change the prices paid by dealers for milk, nor will it increase the total funds available to be paid to producers.

(c) The additional administrative costs involved in calculating bases, notifying producers of their earned bases, paying two prices for milk during four of the twelve months in each year, and other incidental operations resulting from the plan are expected to be negligible.

(d) The estimated effect on price to producers was calculated for the month of May, 1954. If the level production plan had been in effect for this month, the resultant price, or price to producers with bases of 10,000 lb. of milk for the month, but with varying levels of actual production, would have been as follows:

TABLE 4

Example of producer payments for May 1954 based on prices calculated in accordance with terms of the level production plan

Producer	Milk produced			Calculated average price[a] per cwt.	Actual Order 41 price per cwt.	Gain (loss) ¢ per cwt.
	Total lb.	Base lb.	Surplus lb.			
A	10,000	10,000	——	$3.18	$3.05	13
B	12,000	10,000	2,000	3.11	3.05	6
C	14,000	10,000	4,000	3.06	3.05	1
D	16,000	10,000	6,000	3.03	3.05	−2
E	18,000	10,000	8,000	3.00	3.05	−5
F	20,000	10,000	10,000	2.98	3.05	−7
G	30,000	10,000	20,000	2.91	3.05	−14

[a] Calculated base price for May, 1954, was $3.18 per cwt. and the surplus price was $2.78 per cwt.

There are producers now producing for the Chicago market who have all of the above patterns of seasonal production. The table illustrates that gain or loss under the level production plan as against the previous one-price plan is dependent on the producer's seasonality of production as compared to the average seasonality in the milk shed. In order to gain, he must have more level production than average. It is not necessary to produce at almost the same level throughout the year.

These data also show that there is definite incentive to improve, regardless of a producer's present seasonal pattern, unless, of course, his production is already absolutely level.

Objectives of the Plan

The primary objective of the plan is to level production gradually. This does not anticipate either increase or decrease in total production. However, it would involve increases in fall production and decreases in spring production.

Regardless of its effect in leveling production, the plan definitely will reward the producers who now are conforming their production to the needs of the fluid market. It will provide additional incentive for those who are not producing levelly to conform to the market requirements. The price burden of seasonal surplus will shift somewhat to the producers who are creating more than their share of the surplus.

Success of the plan in leveling production would bring additional benefits as follows:

(a) Manufacturing costs in surplus plants would be reduced through use of facilities more nearly at their annual capacity.
(b) The seasonal shift from fall shortage to spring surplus would be reduced, thereby relieving milk handlers of a double burden.
(c) It would place a higher percentage of the annual milk production in the position of being "eligible" for sale in bottles. Sales potential would be increased.
(d) Even though total surplus was not reduced, more level production of butter, powder, cheese, and evaporated milk would reduce storage costs and would provide a more steady flow of product to the market place. This should provide for more orderly marketing and permit the efficient use of greater sales effort.
(e) In total, the costs of providing the market with an adequate supply of milk and of handling surpluses which do develop should be reduced. This would benefit all segments of the market—producers, dealers, and consumers.

The level production plan will be successful only if producers are aware of its potential benefits. This awareness will result from education. Both the educational process and the planning on the farm resulting from it will take time. Quick results in the form of leveling seasonal production are not anticipated. Long-range improvement and benefits can be expected.

ASSOCIATION ANNOUNCEMENT

LETTER FROM THE PRESIDENT OF MICHIGAN STATE COLLEGE

November 23, 1954

Dr. L. A. Moore, President
American Dairy Science Association
Dairy Husbandry Research Laboratory
U. S. Department of Agriculture
Beltsville, Maryland

Dear Dr. Moore:

Michigan State College is gratified that your Association has accepted the invitation to share in the celebration of our Centennial by holding your annual meeting on our campus.

As many of you know, this was the first agricultural college in the nation and as such, the pioneer of the land-grant college movement. Under these circumstances, it is the hope of everyone here that you will look upon your visit to Michigan State as a sort of homecoming; certainly you will be cordially welcomed as representatives of a science and an industry of great importance to agriculture in Michigan and agriculture in the United States.

It is hoped that you will take advantage of the occasion to visit other parts of Michigan and learn for yourselves why this state has won its reputation as a hospitable vacation land.

That your meetings will be profitable and your visit a most pleasant one is the wish of everyone at Michigan State, which is looking forward with keen anticipation to being your host.

Sincerely,

JOHN A. HANNAH
President, Michigan State College

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VOLUME XXXVIII JANUARY, 1955 NUMBER 1

JOURNAL OF DAIRY SCIENCE

ABSTRACTS OF LITERATURE

W. O. Nelson, Abstract Editor

ANIMAL DISEASES

1. Disturbances in acid-base balance and electrolyte in calf diarrhea and their treatment. A report of eighteen cases. B. J. McSHERRY and I. GRINYER, Ont. Vet. Col., Guelph. Am. J. Vet. Research **15**, 57: 535. 1954.

Calves with severe diarrhea tended to have low serum pH, bicarbonate and glucose and high serum potassium and sodium. The latter was considered to be a compensatory shift which actually left the intracellular potassium subnormal, resulting in weakness and stupor. Intraperitoneal injection of a solution containing excess potassium, in comparison to normal serum, but balanced in other electrolytes, was followed by rapid clinical improvement of many calves which had not improved following antibiotic treatment. The treatment for metabolic acidosis and dehydration which occurs in severe diarrhea is just as important as treatment for the infectious agent. E. W. Swanson

2. Virus diarrhea in cattle. J. A. BAKER, C. J. YORK, J. H. GILLESPIE, and G. B. MITCHELL, Cornell Univ., Ithaca, N. Y. Am. J. Vet. Research, **15**, 57: 525. 1954.

Strains of virus were isolated from the spleen and brain of two cows afflicted with virus diarrhea. Inoculation of calves with each strain caused sickness, but on reinoculation the calves were immune to both strains, indicating an antigenic relation. One-fourth of a group of calves secured from dairy farmers were immune when tested by inoculation, but all calves from a strictly isolated herd were susceptible. The disease may therefore be fairly widespread in dairy herds. Inoculation was equally effective by intravenous or intranasal routes.

The typical reactions were an increase in temperature on the 2nd d., with it remaining slightly elevated for 5 d. after which a very high temperature was reached on the 7th or 8th d., followed by return to normal. Leukopenia accompanied the temperature changes. General malaise occurred. Diarrhea developed in only half of the calves, and oral lesions typical of field cases were not found.

The virus concentration in blood and spleen was at its peak at 4 d. when it was 100 times as high as at the time of highest body temperature. The virus could not be grown in incubated eggs, guinea pigs, pigs, dogs, cats, goats, sheep, or mice, but rabbits were susceptible. After repeated passage through rabbits the virus was modified so that it produced only mild symptoms in calves, but did produce immunity against the original virulent virus.

E. W. Swanson

3. The effect of complete milking at calving time on the incidence of milk fever and the subsequent effect on the cow and calf. J. R. OWEN, Miss. Agr. Expt. Sta., State College. Inf. Sheet 497. 1954.

Ayrshire, Guernsey, and Jersey cows used in this experiment were divided into three groups. In the first group calves remained with their dams 3 d. during which time the cows were only partially milked. Calves were removed immediately after birth and the cows milked completely 2 hr. after calving in the second and third groups. The cows of group II were injected with oxytocin to insure complete milk let-down, those of group III received no oxytocin. Six cases of milk fever were reported (all Jersey) in the 56 cows used; 2 in group I, 3 in II, and 1 in III. It was concluded that complete milking at calving has little effect on incidence of milk fever, udder congestion, or the amount of milk produced in the succeeding lactation. R. W. Hunt

4. A preliminary report on hypothyroidism in cattle and its possible relationship with reproductive disorders. R. ALLCROFT, Vet. Lab., Min. of Agr., Weybridge, Surrey; J. SCARNELL, and S. L. HEGNETT, Wellcome Vet. Research Sta., Frant Sussex. Vet. Record, **66**, 26: 367. 1954.

Abnormal thyroid conditions in certain high yielding herds were investigated, since there were indications that this resulted in breeding problems and calves born dead. All aborted fetuses from these herds were examined for pathogenic organisms. The thyroids of these fetuses were weighed and examined and iodine content determined. Plasma protein-bound iodine levels were determined in the cows of both normal and problem herds.

Hypothyroidism, as measured by low plasma protein-bound iodine values, in cattle was dem-

onstrated. A breed difference in the plasma protein-bound iodine levels was found to exist in the 3 breeds studied. Guernseys, Ayrshires, and Holsteins ranked from high to low.

Authors describe the fetal thyroid histology associated with the hypothyroid condition. Low plasma protein-bound iodine values and histological changes in fetal thyroids were associated with a high herd incidence of aborted, stillborn, and weak calves. R. P. Niedermeier

5. Cobalt deficiency in New Hampshire cattle, sheep, and goats. H. A. KEENER, G. P. PERCIVAL, and K. S. MORROW, N. H. Agr. Expt. Sta., Durham. Station Bull. 411. 1954.

Cobalt deficiency was found to affect the health of cattle, sheep, and goats generally throughout New Hampshire. The need for supplemental cobalt is very small, 1 lb. of cobalt sulfate being enough to treat 225 T of feed. Studies now in progress show the cobalt content of forage may be reduced to the deficiency level in heavy yields resulting from the use of chemical fertilizers as well as poultry manure. A high percentage of ladino clover in a mixture is no guarantee against cobalt deficiency. Recent information indicates that the deficiency symptoms in ruminants are due to lowered production of vitamin B_{12} by the rumen flora. The principal symptom is lack of appetite.
R. W. Hunt

BOOK REVIEWS

6. Manual of Field Studies on the Heat Tolerance of Domestic Animals. DOUGLAS H. K. LEE. Food andAgriculture Organization of the United Nations. Columbia University Press, International Documents Service, 2960 Broadway, New York 27, N. Y. 161 pp. $2.00. 1953.

The immediate purpose of this manual is to suggest plans and techniques for the study of heat tolerance of domestic animals in the field. Chapter headings are as follows: (1) General Plan for the Study of Environmental Conditions, (2) Specific Techniques for the Study of Environmental Conditions, (3) General Plan for the Study of Animal Reactions, (4) Animal Reactions Indicating Heat Tolerance, (5) Characters Influencing Heat Tolerance in Animals, (6) Conditions Influencing Animal Reactions, (7) Interpretation of Field Studies and Application to Practical Production, (8) Sources of Instruments Mentioned in Text, and (9) Literature Cited and References for Further Reading.

This manual is well written and profusely illustrated; it should be of great practical value to anyone interested in research on heat tolerance of animals. D. Olds

BUTTER

7. Better butter through controlling pH. ANON. The Milk Prod. J., **45**, 10: 30. 1954.

The need for proper neutralization control in butter-making has long been recognized. To meet this need an electronic pH control system for use in cream neutralization has developed.

The instruments used in measuring, recording, and automatically controlling pH are mounted on a mobile, stainless steel panel. The portable unit consists of an indicating pH amplifier, a pH recorder-controller, an air-operated control valve for regulating the flow of the neutralizer, a solution tank for holding a supply of neutralizer solution, and air compressor for supplying compressed air to the control system, a flow meter and a liquid level indicator.

This instrument measures and records pH, and pneumatically positions a neutralizer valve to the cream line to maintain pH at a constant and predetermined valve. J. J. Janzen

8. De kleinverpakking van boter in aluminum foelie (Retail packaging of butter in aluminum foil). K. J. GROUWSTRA and J. C. T. VAN DEN BERG. Royal Neth. Dairy Federation, The Hague, Holland. 1954.

The retail packaging of butter is discussed. The quality of good butter is inadequately protected by packaging in vegetable parchment papers not impervious to odors, light, acids, or moisture, and which do not give adequate firmness. Vegetable parchment and carton, and aluminum foil gave a better protection. It is desirable to coat the aluminum foil with lacquer or laminate it with vegetable parchment.
W. C. van der Zant

9. Standardization of methods for the analysis of milk and dairy products in the Netherlands. X. Standardization of butter triers. The scientific committee for the standardization of methods for the analysis of milk and dairy products. Neth. Milk & Dairy J., **8**: 143. 1954.

Two types of butter triers used in the Netherlands are discussed in detail. The "short type" is used to obtain a broad core for structure, working, moisture distribution, and organoleptic tests. The "long type" is used for drawing samples from butter in cask to determine the chemical composition. W. C. van der Zant

CHEESE

10. Cheese keeps longer in antimycotic wrapper. H. H. MOTTERN, Kraft Foods Co., Glenview, Ill. Food Eng., **26**, 10: 93. 1954.

The use of 0.3 to 0.45% dimethyl dichlorosuccinate incorporated in Parakote-type cheese wrappers markedly reduced mold growth on the cheese surfaces. Flavor, color, and appearance of cheese were excellent after 12 wk. Vapors of the antimycotic inhibit mold growth with a minimum transfer of the reagent to the cheese. Data show that in ½-lb. packages of cheese a maximum of 2.5 mg. (approx. 11 p.p.m.) of the antimycotic were found. From studies of acute and long term toxicity effects with rats

or mice, it is considered that the small amount of dimethyl dichlorosuccinate present in the cheese has a negligible toxicity. Essentially 100% of radioactive tracers was recovered in the excreta in 48 hr., hence there is no accumulation in vital tissues and organs.

T. J. Claydon

11. An early gas defect in pasteurized milk Cheddar cheese. C. A. ERNSTROM, Univ. of Wis., Madison. The Milk Prod. J., **45**, 11: 21. 1954.

An early gas defect in Cheddar cheese made from properly pasteurized milk has been caused by coliform bacteria. These organisms may be found in contaminated starter, on utensils, and in cheese factory equipment unless special precautions are taken to eliminate them.

Precautions for prevention of this defect include: (1) Proper pasteurization. (2) Use of uncontaminated starter. (3) All factory equipment and utensils must be dismantled and washed daily. (4) Prescribed procedures must be used for cleaning HTST pasteurizers, for washing general equipment and utensils, and for removing milkstone. (5) All factory equipment and utensils must be effectively sanitized immediately preceding their use for handling milk or curd.

The adoption of effective cleaning and sanitizing procedures has eliminated the problem of gassy texture and unclean flavors in Cheddar cheese made from pasteurized milk.

J. J. Janzen

12. New cheese makes possible shortcuts in production. ANON. The Milk Prod. J., **45**, 11: 33. 1954.

A new cheese which shortens the usual methods of producing a mild natural cheese has been developed at the Univ. of Wis. The process can be entirely mechanized and the product is ready for consumption in 3 wk. The cheese is high in moisture and has a distinctive, pleasing, natural cheese flavor.

Cost advantages in view of high yield, mechanization, shorter storage time, and elimination of hand processing, are favorable. Consumer taste testing points to a good sales potential. The cheese has been named "Dariworld."

Dariworld is made by following common process for curd making until the whey is ready to be removed. At that time, the drained curd is covered with warm brine until the proper acidity develops. Then the curd-brine mixture is heated, drained, and hooped. The moisture content may be varied from 42 to 50%. J. J. Janzen

13. Mish: A soft-ripened Egyptian cheese. M. K. HAMDY and S. M. TAHA, Cairo Univ., Egypt. The Milk Prod. J., **45**, 11: 14. 1954.

Mish is a soft-ripened cheese made from skimmilk cheese to which whole milk and other flavoring and nutritive substances are added. The procedure for preparation of Mish is described. The mixture is stored under microaerophilic conditions in an earthen-ware pot for a period of one yr. before it becomes "Mish." Well-ripened Mish has a sharp, pungent taste with a butyric acid odor resembling Romano and Roquefort cheese. During ripening this cheese undergoes a lactic acid fermentation followed by a butyric acid fermentation which gives Mish its characteristic flavor.

J. J. Janzen

14. Lo-Hio low-fat soft-ripened cheese product. ANON. The Milk Prod. J., **45**, 11: 20. 1954.

This low-fat soft-ripened cheese containing buttermilk solids was developed at Ohio State Univ. and is manufactured by a modification of the brick cheese method of Buyens and Price. The cheese cures to a mild flavor at 40° in 6 wk. and has met with considerable enthusiasm in initial consumer acceptance trials.

A six weeks old Lo-Hio contains 25% fat (dry weight basis), 45% moisture, and 2.0% salt, and is at pH 5.2. The cheese yield is 10 to 11 lb/cwt milk. J. J. Janzen

15. Fine points of sanitation that up cottage cheese quality. P. R. ELLIKER, Ore. Agr. Expt. Sta., Corvallis. Food Eng., **26**, 11: 79. 1954.

Fundamentals of manufacturing high quality cottage cheese include: (a) prevention of bacterial contamination, (b) use of active cultures with pleasing aroma and flavor, (c) use of high quality milk and cream, (d) adequate processing facilities and, (e) laboratory control.

Among defects produced by microorganisms are slimy or gelatinous curd, discoloration, yeasty and fruity flavors, and loss of fine flavor. Most spoilage is produced by psychrophiles such as *P. viscosa, P. fragi* and *A. metalkaligenes*. These organisms are present in water and soil and may enter the plant through raw milk and utensils. They are destroyed by proper pasteurization.

To control bacterial contamination, special attention is necessary in sanitizing procedures, particularly with cans and vats. Alkaline cleaners including 100 to 200 p.p.m. of chlorine are effective cleaning agents. Hypochlorites remain the preferable germicide for sanitizing equipment. It is recommended that water used in cottage cheese washing be chlorinated at the rate of 5-10 p.p.m. The pH of the finished product is an important factor in controlling development of contaminating organisms. A pH of about 5.0 is desirable. Easiest means of pH control is the addition of citric acid to the cream. Holding temperatures should not be above 40° F. Keeping quality tests are an absolute necessity. T. J. Claydon

16. Cheese press. K. ZEILER and K. LENZ (assignors to Anton Steinecker Maschinenfabrik A. G.). U. S. Patent 2,691,935. 1 claim.

Oct. 19, 1954. Official Gaz. U. S. Pat. Office, **687**, 3: 544. 1954.

Curd is filled to overflowing into rectangular-shaped divisions of a flat double-walled cheese mold. The partitions separating the individual molds are also double-walled. An inflatable cushion is overlaid on the filled mold and fastened to the outside edge. When inflated, the cushion forces the curd into the molds and any whey expressed from the curd drains away through holes into the space between the molds. The curd may be heated by circulating a hot fluid between the walls. R. Whitaker

17. Cheese curd mechanical processing. B. T. Hexsgen (assignor to Swift & Company). U. S. Patent 2,692,832. 6 claims. Oct. 26, 1954. Official Gaz. U. S. Pat. Office, **687**, 4: 855. 1954.

A centrifuge for separating whey from cheese curd. The whey is discharged, leaving the curd in the centrifuge to be removed and cut later by means of a plow and a curd cutting device. R. Whitaker

18. Apparatus for cutting cheese into small blocks. G. H. Kraft and J. Riemer (assignors to Kraft Foods Co.). U. S. Patent 2,692,430. 5 claims. Oct. 26, 1954. Official Gaz. U. S. Pat. Office, **687**, 4: 738. 1954.

Details are given for a taut wire cutter for slicing cheese. R. Whitaker

CONDENSED AND DRIED MILKS; BY-PRODUCTS

19. Instant-dissolving nonfat dry milk solids. Anon. The Milk Products J., **45**, 11: 24. 1954.

This special report briefly outlines the present status of "Instand-Dissolving" nonfat dry milk solids.

Borden's instant Starlac is marketed in two consumer size packages—a lb. package which makes 5 qt. and a box of 3 individual envelopes, each of which makes a qt. of nonfat milk. The new Instant Milk Co., owned by Carnation and Western Condensing, proposes to sell its product under the Cariation label. Pet Milk Co. also has started marketing its own brand of instant nonfat dry milk powder. Maple Island Inc., Stillwater, Minn. expects to put their product on the market very soon.

Other developments in the industry also may affect manufacturers. It has been reported that homogenized milk dried just above the freezing point is far more soluble than the highest quality whole milk dried by present methods.

A new process has been described in which nonfat dry milk solids are incorporated into cream, mixed to form a mush, and the resulting product frozen solid. It can be stored frozen and ½ pt. mixed with water produces 1½ qt. of drink that looks and tastes like natural whole milk. J. J. Janzen

20. New process produces instant non-fat dry milk. C. R. Havighorst. Food Eng., **26**, 10: 74. 1954.

The product is marketed as "Carnation Instant Milk." Only a generalization of the process is publicly available at present. The procedure involves reprocessing spray-dried powder to an adjusted moisture content and sponge-like texture. The product is then dried in tray-type continuous driers to 3-3.5% moisture. All handling operations are designed to protect the porous structure. Instant milk dissolves very quickly and completely, even in ice water. It is free-flowing and does not cake in packages. It does not foam when reconstituted.

T. J. Claydon

21. De invloed van temperatuur en vochtgehalte op de duurzaamheid van verstuivingspoeder uit volle melk (The effect of storage temperature and moisture content on the keeping quality of spray dried whole milk powder). L. Radema. Neth. Milk & Dairy J., **8**: 125. 1954.

Powders from 5 different factories were stored at 9, 20, 30, and 37° C. for 1 yr. After 35, 100, 200, and 300 d., samples were taken for flavor and peroxide determinations. After 300 d. the thiobarbituric acid test for fat oxidation, the test for ferricyanide reducing groups, and color determinations were performed. The keeping quality decreased with high storage temp. A low moisture content promoted the development of a tallowy flavor; a high moisture content promoted a glue-like flavor. The peroxide values correlated with the tallowy flavor. A negative correlation was observed between the peroxide values for the glue-like flavor. The T.B.A. test gave a distinct value when the oxidative defects were pronounced. The tallowy flavor was due to oxidation, the glue-like flavor was not. The ferricyanide test was positive only when the powders had a strong glue-like flavor. The powders with a strong glue-like flavor were blue in ultraviolet light; the fresh powders were yellow. W. C. van der Zant

DAIRY BACTERIOLOGY

22. Effect of milk and other dairy products on the thermal inactivation of coxsackie viruses. A. S. Kaplan and J. L. Melnick, Yale Univ. School of Med., New Haven, Conn. Am. J. Pub. Health, **44**, 9: 1174. 1954.

Milk, cream, and ice cream mix were found to offer some protection against heat inactivation of coxsackie viruses. When suspended in milk, 3 human fecal strains and 2 mouse-passaged strains of the virus were inactivated by 61.7° C. for 30 min.; 71.1° C. for 15 sec. inactivated the 3 human fecal strains. One mouse-passaged strain (Tex.-1) survived 71.1° C. for 20 sec. but not for 30 sec. This strain suspended in ice cream mix survived heating for 30 min. at 65.2° C., but not at 67.7° C., and it was inac-

tivated in 15 sec. at 71.1° C. by HTST pasteurization.

Cream was more effective than either milk or ice cream mix in protecting the virus against thermal inactivation. The Tex.-1 virus was readily detectable after heating at 71.1° C. up to 60 sec., and a trace of virus was found after 75 sec. This strain still was infectious after being heated in cream for 30 min. at 67.7° C. and even slightly so at 71.1° C. but it did not survive 72.1° C. The 3 viruses from human sources did not survive 71.7° C. for 30 min. or 71.1° C. for 15 sec. when suspended in cream.

D. Deane

23. The influence of cobalt on the action of antibiotics. J. C. Trace and G. T. Edds, Ft. Dodge Lab., Ft. Dodge, Iowa. Am. J. Vet. Research, **15**, 57: 639. 1954.

Several antibiotics were tested for in vitro effectiveness against *M. pyogenes* singly and in combination, and with and without added Co. A level of 0.3μg. of $CoSO_4 \cdot 7H_2O$ per ml. was used. Cobalt was of no added value with chloramphenicol, chlortetracycline, oxytetracycline, or polymixin. It increased the effectiveness of penicillin, streptomycin, and bacitracin 2 to 3 times. In a mixture of penicillin, streptomycin, sulfathiazole, and sulfisoxazole cobalt increased effectiveness 2 to 10 times against *M. pyogenes, E. coli, A. aerogenes,* and *P. aeruginosa,* all of which had been isolated from clinical mastitis.

E. W. Swanson

24. Petri dish and improved cover therefor. R. I. Fletcher. U. S. Patent 2,694,033. 6 claims. Nov. 9, 1954. Official Gaz. U. S. Pat. Office, **688**, 2: 365. 1954.

A cover for a petri dish is described, the inside surface sloping from the outer rim toward the center. Any condensed moisture on the cover is thereby induced to collect at the center, where it is held by a ring of absorbent material surrounding a stud molded in the center of the cover, thus preventing the condensed water from falling on the culture growth.

R. Whitaker

25. Standardization of methods for the analysis of milk and dairy products in the Netherlands. IX. The plate count of bacteria in milk. The scientific committee for the standardization of methods for the analysis of milk and dairy products. Neth. Milk & Dairy J., **8**: 139. 1954.

A detailed description is presented of the materials used in carrying out the plate count. TGEM agar is used as the plating medium. Tranfers of less than 0.5 ml. of milk or dilutions thereof in the preparation of dilutions or Petri dishes are not allowed. The plates are incubated for 3 d. at 30 ± 2° C.

W. C. van der Zant

26. Bacteriological requirements for and testing of sterilized milk and sterilized milk products. D. A. A. Mossel and E. F. Drion. Neth. Milk & Dairy J., **8**: 106. 1954.

It is recommended that commercially "sterilized" milk shall be sterile, since no inhibitory factors such as NaCl, $NaNO_2$, peroxidic lipids, etc., which prevent germination of surviving spores, are present in heated milk. The following procedure is recommended for testing sterilized milk: Samples are stored for at least 7 d. at 32° C. and 10 d. at 55° C. After incubation the contents should be free of souring, curdling, putrefaction, gas formation, and clot on boiling. Triplicate pour plates are made using 1 and 0.1 ml. of milk per plate in the following agars: (a) 0.5% tryptone, 0.1% dextrose, 0.25% yeast extract, and 0.1% soluble starch, and (b) a suitable anaerobic solid medium. Blanks are run to check asepsis of sampling and plating technique. After incubation for 3 d. at the storage temp. of the milk, the ave. number of colonies should not exceed the ave. number of colonies on the blank plates multiplied by 5.

W. C. van der Zant

DAIRY CHEMISTRY

27. Quantitative determination of sugars on paper chromatograms by a reflectance method. R. M. McCready and E. A. McComb, Western Utilization Research Br., Agr. Research Ser., U. S. D. A., Albany 6, Cal. Analyt. Chem., **26**, 10: 1645. 1954.

Direct reflection density measurements on paper chromatograms of the colored spots developed from reducing sugars and aniline-trichloroacetic acid, or fructose and derivatives with acid-resorcinol, have been found to be reproducible and to follow a linear relationship between the logarithm of the sugar concentration and the reflection density. Spectrophotometric reflectance curves and colors produced on paper chromatograms by galacturonic acid, galactose and arabinose are presented. Photovolt reflection density values when plotted against the logarithm of the amount of sugar (between a concentration of 0.5-2%) fell on a straight line.

B. H. Webb

28. "Tracers" seen as answer in detecting foreign-fats. W. Fitelson, Fitelson Lab., Inc., New York. Food Eng., **26**, 10: 109. 1954.

After considering principles and limitations of various tests for foreign-fat detection, the author concludes that the use of "tracer" substances added to non-dairy fats and oils is the most promising approach to detecting and controlling adulteration of dairy products. Such tracers must be fat-soluble, non-toxic, and never found in butterfat or dairy products. Sesame oil has been used in Europe and India as a required additive to oleomargarine and shortenings, and it may be readily detected.

Butylated hydroxyanisole and tyrosine ethyl ester also are suggested as suitable tracers. Sensitive methods for their detection in small amounts have been published. T. J. Claydon

29. Standardization of methods for the analysis of milk and dairy products in the Netherlands. VIII. The peroxidase (Storch's) test. The scientific committee for the standardization of methods for the analysis of milk and dairy products. Neth. Milk & Dairy J., **8**: 136. 1954.

A detailed description of the reagents and procedure for carrying out the peroxidase test is presented. W. C. van der Zant

30. Drying of yeast to inactivate zymase and preserve lactase. E. G. STIMPSON (assignor to National Dairy Research Laboratories, Inc.). U. S. Patent 2,693,440. 2 claims. Nov. 2, 1954. Official Gaz. U. S. Pat. Office, **688**, 1: 165. 1954.

An aqueous yeast preparation is spray dried in a temperature range of 130-310° F. to inactivate the zymase and allow the recovery of an active lactase product. R. Whitaker

DAIRY ENGINEERING

31. New controls presage automatic dairy processes. L. E. SLATER, New York, N. Y. Food Eng., **26**, 10: 78. 1954.

Automatic dairy processing is dependent upon more critical control of processing temperatures, exact regulation of product flow through the plant, and techniques to gage product quality in-stream. Improvements have been made in temperature control, for pasteurizing, drying, and freezing. The modified Rotometer has accomplished flow measuring. Progress is being made in developing accurate and sanitary throttling valves to give automatic flow control and several instruments are available. In gaging product quality in-stream, the Robichaux continuous pH standardizer is an example of equipment being developed. The control of fat content in cream from the separator is achieved by the Brookfield temperature-compensated in-line viscosimeter. Other approaches are being tried to control overrun in ice cream manufacture. T. J. Claydon

32. Automatic filling and weighing machine. D. O. JOHNSON and F. A. JOHNSON (assignors to Foremost Dairies, Inc.). U. S. Patent 2,693,336. 6 claims. Nov. 2, 1954. Official Gaz. U. S. Pat. Office, **688**, 1: 141. 1954.

An automatic electrically operated system of placing a predetermined weight of material, such as milk powder, in cartons as they progress on a conveyor. R. Whitaker

DAIRY PLANT MANAGEMENT AND ECONOMICS

33. Economies of scale in the operation of can and tank milk receiving rooms, with special reference to Western Washington. E. L. BAUM, R. D. RILEY, and E. E. WEEKS, Wash. Agr. Expt. Sta., Pullman. Tech. Bull. 12. 1954.

Due to the continually larger proportion of Grade A milk being used in the Class I market, this study was undertaken to answer some of the economic questions which must be considered in planning a change in operations or the construction of a new receiving room. Model receiving plants were conceived on paper with their capacities ranging from 120 to 1,540 cwt. per day. Short term and long term unit costs were determined for each size plant. Considerable information has been assembled to show how the unit cost are derived and their applications to an operating receiving room. R. W. Hunt

34. Manufacturing costs, finished product values in butter-powder and cheese plants. G. T. NELSON, Ore. State Coll., Corvallis. The Milk Prod. J., **45**, 11: 17. 1954.

Manufacturing costs in large plants are as much as 44% lower than in small plants. Costs average 20% higher in spray process than in roller process powder plants. Butter-Spray process powder costs are about 34% higher than in cheese plants of comparable volume. Net values of finished products are approx. the same in butter-spray powder and cheese plants with butter priced at 65¢, powder 16¢, and cheese 38¢ per lb. J. J. Janzen

35. Consumer milk drinking habits. ANON. Milk Dealer, **44**, 1: 80. 1954.

A survey by ADA shows that 7% more people were drinking milk this spring than last fall. In evaluating all beverages, 54% of the consumers said vitamins were the most important factor as compared with 39.9% for calcium, 28.3% for minerals, 27.4% for proteins, and 25.6% for easy digestion. The survey showed that 88.3% of the milk is consumed at home. Twenty % of the consumers drink 3 or more glasses of milk a day, 21.8%—2 glasses a day, and 57.8% drank 1 glass or less a day. Of those interviewed, 49.2% said that milk was not fattening, 31.4% said that it was and 19.4% didn't know. Only 18.1% said that they had heard of whole milk as the main food in reducing diets and 41.5% had heard of skimmilk in that respect. C. J. Babcock

36. Keeping sunlight off of milk delivery trucks. ANON. Milk Dealer, **44**, 1: 60. 1954.

Sunlight streaming through truck windows on milk in transit can cause an oxidized flavor

in a short time. Thompson's Dairy in Washington, D. C. installed shade screens on about 40 trucks, and tests indicate that the screen practically stops 100% of the sunlight in the summer time from 8:00 a.m. to 4:00 p.m. When the angle of the sun's rays with the horizon is 45° and 37° the effectiveness of the aluminum louvered screen in blocking the sun's rays is actually 100%. The effectiveness at 30° is 85%, 75% at 25°, 55% at 15°, and 30% at 0°. The screen is most effective during the hottest hours of the extreme heat period of May 1 to Aug. 1. In winter months, fixed louvers and relatively low sun angle permit more light to enter the trucks. C. J. Babcock

37. Bulk handling aids processor, too. F. M. Bigwood and W. I. Walsh, Dairymen's League Coop. Assn., Inc., Buffalo, N. Y. Food Eng., **26**, 10: 100. 1954.

When bulk-milk handling is operated on a 100% basis considerable savings may be effected, chiefly through elimination of weigh-room equipment and operations. At Dairylea's Carrigan branch, Niagara Falls, N. Y., savings were as follows: (1) refrigeration, 75 ton hr. daily, (2) fuel, 15 to 20%, (3) electric power, 5%, (4) labor, 6 man-hours daily, (5) cleaning materials, $15.00 to $20.00 per month, (6) depreciation on cans, approx. $900 per year, (7) depreciation and maintenance of receiving can washing, and conveying equipment. In addition, bacteria counts of incoming milk were lower, extra space was available, and public relations were improved. T. J. Claydon

38. Challenging changes. They demand "doing" by dairymen. I. A. Gould, Ohio State Univ., Columbus. Food Eng., **26**, 10: 70. 1954.

The author reviews the changes occurring in the dairy field and appraises the challenges presented. Consideration is given to developments in production, procurement, processing, distribution and merchandizing, consumption, and personnel. Able leadership is essential in evaluating current trends logically and close cooperation between dairy groups is necessary to meet effectively the problems creation.
T. J. Claydon

39. 40 years of service. E. K. Slatter. The Milk Prod. J., **45**, 10: 34. 1954.

The National Dairy Council has been a leading force in selling the idea of better nutrition through greater use of milk and milk products in the daily diet. This has been accomplished through a long-range nutrition research and education program, public relations, and publicity activities.

This article reviews some of the events that led to the development of NDC in 1915 and some of its early organizational work through 1919. J. J. Janzen

40. 3 in 1 plant. Anon. The Milk Prod. J., **45**, 10: 24. 1954.

A model surplus milk plant at Madison, Wis., is a receiving plant, cheese factory, and a retail outlet. Surplus milk from the local fluid milk-shed is utilized primarily for Swiss and Cheddar cheese production with a limited use in brick and cream cheese.

The retail store serves light dairy lunches, and also has cheese and ice cream cabinets for takeout service. Seating capacity is 46 persons on stools and in booths.

In the fall the firm prepares gift cheese packages. This business is concentrated primarily on industrial concerns. Ninety % of the business is repeat business. Some wholesale gift cheese packaging for other shippers also is practiced. J. J. Janzen

41. Plastic milk tank-trailer. Anon. Food Eng., **26**, 10: 97. 1954.

Three plastic trailer-tanks are in use at Dairymen's League Coop. Assn., Inc., of New York City. The tank includes a thin stainless steel inner liner meeting sanitary regulations and permitting normal cleaning procedures. A plastic shell encases the stainless steel liner. A 2-in. thick layer of balsa wood provides insulation and a second plastic layer forms the outside shell. The tank has exceptional structural strength and is of lighter weight than stainless steel tanks of equal capacity. The plastic absorbs road shocks better than steel. Advantages of the tank are its longer life, less costly maintenance, and greater pay-loads.
T. J. Claydon

42. Highest vending sales ever. Anon. Milk Dealer, **44**, 1: 62. 1954.

Land O'Lakes Creamery Inc. began vending machine operations in 1952 with the installation of 7 machines. In 1953, 18 more were added. Today 25 machines are located in the suburban Twin Cities and 13 in the Faribault, Minn. area. In the Twin Cities, 10 machines are doubles and 15 are singles. In Faribault all the machines are single. The single unit holds 500 ½-gal. containers and the double unit 1,000 ½-gal. containers. Points to consider in selecting locations for vending machines and cost summary analysis are given.
C. J. Babcock

FEEDS AND FEEDING

43. The effect of method of administration on the absorption and storage of vitamin A by dairy calves. N. L. Jacobson, R. S. Allen, J. T. Blake, and P. G. Homeyer. J. Nutr., **54**, 1: 143. 1954.

Vitamin A absorption and storage were much greater from an aqueous dispersion than from an oily solution. There was an indication that

administration of vitamin A in milk by nipple feeder resulted in more efficient utilization than administration by capsule. O. T. Stallcup

44. Design and conduct of calf nutrition studies. I. One versus two and three day growth measurements. C. M. Dembiczak, H. D. Eaton, G. Beall, and H. L. Lucas, Storrs Agr. Expt. Sta. and Univ. of Conn., Storrs, and N. C. State Coll., Raleigh. Presented at meeting of Eastern Div. A.D.S.A. Sept. 19, 1954.

A series of three successive daily measurements of five growth criteria were taken on 48 calves at weekly intervals for 13 wk., begimming on the 6th, 7th, and 8th d. and ending on the 90th, 91st, and 92nd d. of age. The calves raised on a limited whole milk-calf starter system, consisted of eight groups of six animals identical with respect to breed (Guernsey or Holstein), sex, and year (1951 or 1952) on experiment.

Comparisons of the size of the within group error for one and two-day, two and three-day, and one and three-day ave. measurements were made by the t-test applying the Pitman-Morgan correction for correlated data. The within group error was obtained for each criterion from three series of 12 individual analyses of variance of the differences in the 1st week's measurements from those taken on the 2nd, 3rd, 4th . . . 13th wk.

A single measurement was found sufficient to determine physical growth changes for live weight, heart girth, and girth of paunch; three measurements were found to be significantly better than one or two for length from withers to pin bones; and inconclusive results were obtained for height at withers. Age had no effect on the ratio of the within group errors of single to the ave. of two and three-day measurements except in the case of girth of paunch for which the ratio was reduced with age. For each of the criteria the coefficients of variation of single, 2-day-ave., and 3-day-ave., measurements decreased in size as the age interval was increased to approximately 42 d.; increasing the interval beyond this point made no appreciable difference in the coefficients of variation. An attempt to use a breakdown of the error into its component parts of measurement and sampling error was unsuccessful as there was no known method to correct for existing correlation in the data. Authors' Abstract

45. Calves prefer pelleted hay. K. E. Gardner and W. F. Akers. Hoard's Dairyman, **99**, 23: 1063. 1954.

Dairy calves at the Ill. Agr. Expt. Sta. were fed long, chopped, ground, and pelleted third cutting alfalfa hay for the first 16 wk. of life. Each calf had 340 lb. whole milk and a calf starter made up of 35% ground shelled corn, 30% crushed oats, 15% linseed oil meal, 10% dried skin milk, 6% soybean oil meal, 2% wheat bran with added salt, steamed bone meal, and vitamin A and D supplement.

The 13 calves getting long hay ate 114 lb. of hay and 255 lb. of starter. The 11 calves fed chopped hay ate 126 lb. of hay and 243 lb. of starter. A group of 12 calves ate 152 lb. of ground hay and 211 lb. of starter. Another group of 12 calves ate 268 lb. of pelleted hay and 171 lb. of starter.

The digestibility of the various feeds in these rations showed no real difference. The calves eating pelleted hay showed the largest gains in wt., averaging 1.54 lb. daily for the experimental period. A. R. Porter

46. "Steaming-up" may not pay. W. B. Nevens. Hoard's Dairyman, **99**, 23: 1045. 1954.

Eighteen cows and 18 first calf heifers were divided into two groups as nearly alike as possible at the Ill. Agr. Expt. Sta. One group of 9 cows and 9 heifers was fed no grain during the dry period preceding calving. The cows in the other group were each fed 378 lb. of concentrates in the 42 d. before freshening and the heifers 273 lb. in the same period. All experimental animals were fed good alfalfa hay at the rate of 1½ lb. daily per 100 lb. liveweight and 2 lb. of corn silage daily per 100 lb. liveweight.

The control animals averaged 43 lb. gain in wt. per head and the "steamed-up" animals gained 73 lb. each. In the first 84 d. following calving the control animals averaged 43.8 lb. of milk daily. The "steamed-up" animals averaged 43.6 lb. No important difference between the groups was noted in the appearance of the udders. The "steamed-up" cows had more cases of milk fever, ketosis, and mastitis.

A. R. Porter

47. Grass silage: A reappraisal. J. G. Archibald, M. L. Blaisdell, B. Gersten, and D. M. Kinsman, Mass. Agr. Expt. Sta., Amherst. Bull. 477. 1954.

A summary of 18 yr. experience with grass silage at the Experiment Sation is included in this bulletin. Results show good quality grass silage is indicated by (a) a pH of 4.5 or less, (b) low volatile base content (0.5% or less expressed as ammonia), (c) lactic acid content of 3 to 5% or more, and (d) butyric acid content of 2% or less. The water content of the unensiled crop is the most important single factor. Below 60%, the crop is too dry to pack well, and pockets of mold develop. Above 70%, a risk prevails in regard to spoilage unless a preservative is used or the newly cut material is allowed to wilt. Wilting is only practicable under ideal conditions.

Preservatives fall into two classes: (1) those that add fermentable carbohydrate and thus promote the lactic acid type of fermentation, and (2) those that have a mild antiseptic action.

Examples of the first class are molasses and ground cereal grains; the second class are liquid sulfur dioxide and sodium bisulfite. Citrus meal, beet pulp, and chopped hay are used to absorb excess moisture and in this way act as a conditioner. Because of the difficulty of applying, molasses is no longer recommended. Water, pH, and protein are the only tests needed to determine quality. Palatability is not an infallible quality. Cows sometimes relished very strong smelling silage which tested low in feeding value and which had undergone extensive losses in the silo. R. W. Hunt

48. Geensileerde versus gedroogde suikerbietenpulp. Een voederproef met melkkoeien (Ensiled versus dried sugarbeet pulp. A feeding trial with milkcows). J. GRASHUIS and E. E. VAN KOETSVELD. Communication from the Inst. of Animal Nutr. "De Schothorst," Hoogland, Holland. 1953.

In this experiment 16 cows divided in two groups were used. Group 1 received daily 3 kg. hay, 3 kg. dried grass, 3 kg. dried pulp, chaff, and concentrate according to production and weight. Group 2 received the same ration except that dried pulp was replaced with an equal amount (calculated on dry weight) of ensiled pulp. The food value of dried pulp was the same as that of the ensiled pulp calculated on the dry material. The state of the pulp had no effect on the acid value of the butterfat. The RMW number of the fat from the group receiving ensiled pulp was higher.

W. C. van der Zant

GENETICS AND BREEDING

49. Crystallization patterns in vaginal and cervical mucus smears as related to bovine ovarian activity and pregnancy. J. F. BONE, Ore. Agr. Exp. Sta., Corvallis. Am. J. Vet. Research, **15**, 57: 542. 1954.

Mucus samples, collected carefully from the cervix, spread on clean glass microscope slides and allowed to dry show fernlike crystallization or absence of it according to ovarian activity. Using this test on 183 cows detected 97.7% of the pregnant cows by reason of a lack of fernlike crystallization. Of the non-pregnant cows, only 72.8% were detected by presence of the fernlike pattern. The latter false tests were due to high luteal activity, either from persistent corpus luteum, or from cows in the luteal anestrus phase. With adequate examination and histories such false tests can be detected. The test has promise as a pregnancy test, and is accurate in the first month of gestation. False negatives (fernlike crystallizations) can be caused by contamination of the mucus with many halogen containing compounds, including human perspiration, vaginal secretions, and disinfectants. With proper care the test is a good indicator of ovarian activity.

E. W. Swanson

50. Longevity of dairy cows within a Holstein-Friesian herd: An estimate of its heritability and its relationship with breeding efficiency. C. J. WILCOX and K. O. PFAU, Rutgers Univ., New Brunswick, N. J. Presented at meeting of the Eastern Div., A.D.S.A., Sept 19, 1954.

The records of the Holstein herd known as Overbrook Dairy, Cedar Grove, N. J., covering the period from 1923 to 1953 were studied and analyzed to obtain a heritability estimate for longevity and to determine this character's relationship with breeding efficiency.

Longevity within cows was evaluated in terms of number of apparently normal, or successful parturitions. Included in the study were only those cows which left the herd after passing expected usefulness but not those which were removed because of obviously environmental causes. Employing covariance methods the correlations and regressions of daughters on dams of six sire groups were calculated. The intra-sire regression amounted to +0.187 (significant) with a corresponding heritability estimate of 0.374.

Breeding efficiency within cows was expressed as a percentage derived from the ratio of the actual average calving interval in days to the ideal of 365 days. As in the case of longevity, similar requirements in the collection of the data were specified. Adhering to the same methods of analysis, the intra-sire relationships between dams and daughters were determined and yielded an average regression coefficient of +0.162 (significant). The corresponding heritability estimate amounted, therefore, to 0.324. These results compared favorably with those of other and more extensive investigations in the same herd.

The association between longevity and breeding efficiency within 422 available cows yielded a correlation of +0.034 (insignificant). When 136 cows, whose reproductive life was definitely affected by environmental causes, were excluded from the analysis, 286 females remained. The respective correlation within these amounted to −0.010 (insignificant).

It was concluded that longevity and breeding efficiency are considerably and definitely influenced by the genetic constitution of the cows in this herd. The insignificantly low correlations indicate an absence of important interaction of genetic origin between these two characteristics. While each has a definite place in a breeding program, selection for one will have practically no effect on the other.

Authors' Abstract

51. Electrical ejaculation in the bull. L. E. ROWSON and M. I. MURDOCH. Vet. Record, **66**, 23: 326. 1954.

A modification of the Thibault rectal electrodes (a series of copper rings connected in

pairs) for electrical ejaculation is described. Small copper ring electrodes worn on the index and forefinger of rubber-gloved hand are held on either side of the ampullae by rectal insertion of the hand. Stimulation applied through such electrodes was very successful in producing large volumes of good quality semen. This type of application caused very little general reaction in the animal. This simple, cheap apparatus is being used routinely on certain bulls at the Cambridge Artificial Insemination Center.

R. P. Niedermeier

52. The survival of pathogenic bacteria in bovine semen preserved by freezing. J. W. MacPherson and N. A. Fish, Ont. Vet. Coll., Guelph, Am. J. Vet. Research, **15**, 57: 548. 1954.

The livability of four species of bacteria, *L. monocytogenes, B. abortus, C. pyogenes,* and *V. fetus* was tested after storage in yolk–citrate and milk diluents for bovine semen. Each diluent was stored 3 d. at 5° C. and 7 d. at –79° C. with and without antibiotic additions of 1000 units of penicillin and 500μg. of streptomycin per cc. Viable bacteria of all four species were recovered from all treated and control samples, but it was necessary to remove the antibiotics by washing before growth developed from the antibiotic treated samples.

E. W. Swanson

HERD MANAGEMENT

53. Hydrolytic rancidity induced by pipeline milkers. L. A. Kelley and W. L. Dunkley, Dept. of Dairy Ind., Univ. of Cal., Davis. J. Milk and Food Technol., **17**, 10: 306. 1954.

Methods have been proposed to reduce hydrolytic rancidity induced by pipeline milkers. The common causes of rancidity are admission of air to the milk line, low milk flow-rate, elevation of warm milk under vacuum with air bubbling through it, inclusion of a filter and numerous fittings in the vacuum section of the milk line and continuous operation of a starved centrifugal pump. H. H. Weiser

54. Production efficiency on New England dairy farms. G. E. Frick, S. B. Weeks, and I. F. Fellows, N. H. Agr. Expt. Sta., Durham. Station Bull. 407. 1954.

This bulletin is one of a series of four concerned with efficiency of New England dairy farms. The first dealt with opportunities for reducing costs, the second and third with economies of scale of operations and of the barn-finishing method of harvesting hay. This one deals with the efficient use of machinery and equipment.

The problem of fitting equipment to most New England farms is a major farm-management problem. An analysis was made to determine the optimum combination of equipment and the best ownership pattern for 1-man, 2-man, or 3-man farms. On the 1-man farm, all operations requiring field equipment may be done profitably through custom hiring if the labor saved has an alternative productive use. As the farms increase in size, the advantage of custom hiring is reduced, but on all size farms, some types of custom work may be done profitably. Joint ownership of equipment is another method of reducing high investment costs. However, problems associated with joint ownership often offset any economic advantage. Certain foundational machinery should be considered on most all dairy farms. These items would be a tractor, manure spreader, and mowing machine. R. W. Hunt

55. Hay harvesting methods and costs. K. A. Vary, Mich. Agr. Expt. Sta., East Lansing. Special Bull. 392. 1954.

No one hay-harvesting method was found to be the best for all farms. In the study reported, the average amount of hay moved from field to storage in one hr. varied from 1.4 to 3.0 T. The average for the hayloader and buckrake method was 1.4 to 1.6 T/hr., as compared with 1.5 to 3.0 T using the baler and field-chopper. The average costs of harvesting a ton of hay by the former methods was $4.52 and $4.55 respectively. The latter costs were $4.50 to $8.37. Farmers having less than 50 T of hay annually would do well to consider the buckrake and hayloader or custom hire. Where the operation is on a larger scale and hay is to be sold or moved from one place to another, baling has an advantage. Field chopping is the easiest and fastest method. R. W. Hunt

56. Economics of grassland farming. K. A. Vary, Mich. Agr. Expt. Sta., East Lansing. Special Bull. 391. 1954.

This publication deals with the changes in farm organization, investment, costs and returns resulting from a change in the grass program on an individual farm. A farmer thinking of shifting his present acreage of hay and pasture, should consider the possible effects this change may have on his farm organization and earnings. Figures assembled for this bulletin showed that when a shift was made toward more grass, the farm earnings became increasingly dependent on the efficient utilization of grass. Often, the only market for grass is on the farm where it is produced, mostly through livestock or sometimes as green manure or seed crop. Increased grass will affect requirements for labor, investment, expenses, skill, and managerial ability. Livestock and livestock housing investment may be greatly increased in shifting to more acres of grass. This study indicates that one planning to shift to grassland farming should first estimate the changes in farm organization and earnings which are likely to occur.

R. W. Hunt

57. Milk handling—can or bulk tank? T. A. BAKER, W. E. MCDANIEL, and B. L. BONDURANT, Del. Agr. Expt. Sta., Newark. Cir. No. 29. 1954.

Certain factors should be considered by the farmer before he purchases a bulk tank. These are: (1) the purchase price and installation cost, (2) changes in wiring, (3) interest rate on borrowed purchase money, (4) additional cost in maintaining farm lane for tank truck, (5) working time saved, (6) elimination of physical strain in handling 10-gal. cans, (7) reduction in milk loss, (8) possible reduction in electricity cost, and (9) reduction in hauling rate. Actual results show no difference between the Babcock butterfat test of milk on the farm and that at the plant when the milk was transported in 10-gal. cans. A slight loss of milk occurs between the farm and the plant when 10-gal. cans are used. This loss, borne by the farmer, would be eliminated with a bulk tank. Unless pipe lines are used in a stanchion barn, little time will be saved by use of a bulk tank. Any saving in electrical energy will depend on the selection of the proper size tank.

R. W. Hunt

58. Spray type milk cooler. R. A. HEIM (assignor to International Harvester Co.). U. S. Patent 2,694,298. 9 claims. Nov. 16, 1954. Official Gaz. U. S. Pat. Office, **688**, 3: 498. 1954.

An insulated cabinet type milk can cooler for farm use is described having a refrigeration system, a rack for holding the cans which may be rotated about a post to facilitate loading the cans in the cooler, and a pump for spraying cooled liquid from the bottom of the cabinet over the cans of milk. R. Whitaker

59. Teat cup for milking machines. H. W. HEIM (assignor to International Harvester Co.). U. S. Patent 2,694,379. 5 claims. Nov. 16, 1954. Official Gaz. U. S. Pat. Office, **688**, 3: 518. 1954.

A device for admitting and interrupting the vacuum supply to a milker, based on the position of the teat cup casing in relation to the claw. R. Whitaker

60. Milk claw with shutoff valve for vacuum connection. W. H. HARSTICK (assignor to International Harvester Co.). U. S. Patent 2,694,380. 10 claims. Nov. 16, 1954. Official Gaz. U. S. Pat. Office, **688**, 3: 519. 1954.

A valve for controlling the vacuum supply to a milking machine teat cluster.

R. Whitaker

61. Suspended milker. E. RAWSON (assignor to Package Machinery Co.). U. S. Patent 2,693,703. 15 claims. Nov. 9, 1954. Official Gaz. U. S. Pat. Office, **688**, 2: 282. 1954.

A milk reservoir for a milking machine consisting of a receiver open at one end, to which is clamped a vessel in a horizontal position. When the two units contain the desired amount of milk, they are up-ended and the milker detached, leaving the milk in the vessel. A suitable handle is provided. The use of a clear plastic gasket between the two units allows the operator to note the quantity of milk at any time. R. Whitaker

62. Milking pail unit. K. E. RAPP. U. S. Patent 2,692,576. 10 claims. Oct. 26, 1954. Official Gaz. U. S. Pat. Office, **687**, 4: 781. 1954.

A self-contained unit for use with a milking machine, including a handle, milk receiver, pulsator, hose fittings, etc. R. Whitaker

63. Parlor stall. C. A. THOMAS (assignor to Babson Bros. Co.). U. S. Patent 2,692,577. 12 claims. Oct. 26, 1954. Official Gaz. U. S. Pat. Office, **687**, 4: 781. 1954.

A two-level milking stall is described, the operator standing on a level lower than the cow. R. Whitaker

64. Stock watering trough. T. A. OVERBY and J. G. OVERBY. U. S. Patent 2,692,579. 6 claims. Oct. 26, 1954. Official Gaz. U. S. Pat. Office, **687**, 4: 781. 1954.

A watering trough for cattle, consisting of a tank with a heating element to warm the water when desired and a level controlled supply of water. R. Whitaker

65. Hay drying. M. E. SINGLEY, B. R. POULTON, and D. R. MACKAY, N. J. Agr. Expt. Sta., New Brunswick. Cir. 555. 1954.

Types and specifications of hay dryers are discussed. R. W. Hunt

ICE CREAM

66. Edible container for frozen confections and process for preparing the same. E. L. WASHBURN (assignor to Illinois Development Laboratories, Inc.). U. S. Patent 2,694,012. 12 claims. Nov. 9, 1954. Official Gaz. U. S. Pat. Office, **688**, 2: 362. 1954.

Ice cream cones, cups, etc. are made by baking and toasting a mixture of cereal flour and 3-15% by wt. on the dry basis, of a hydrophilic gelatinous substance. It is claimed that such a product does not become soggy when exposed to high humidity. R. Whitaker

67. Organoleptic, chemical, and bacteriological examination of soft ice milk. W. C. VAN DER ZANT and A. V. MOORE, Texas Agr. Expt. Sta., College Station. Ice Cream Rev., **38**, 4: 48. 1954.

Results of an examination on 50 soft ice milk samples obtained from freezer operators located in 19 Texas cities are reported. Each sample of ice milk was examined for flavor, body and texture, melting quality, fat and total solids,

per cent overrun, acidity, sediment, pasteurization efficiency, and bacteriological quality.

It was found that only 16% of the samples were classified as good on the basis of flavor quality. The most common flavor criticism was unnatural flavoring. Fifty-eight per cent of the samples were classified as perfect or good with respect to body and texture and 62% of the samples were found to have perfect melt-down characteristics. Coarse and weak were the most common criticisms pertaining to body and texture, and curdy was the defect observed most frequently in the melting quality of the samples.

The fat content ranged from 2.1% to 6.8% with 68% of the samples containing from 4.1% to 6% fat. Total solids varied from 27.2% to 36.9%, with 82% of the samples containing from 29 to 34.9% total solids.

Fifty-eight % of the samples had titratable acidities between 0.16 and 0.24 per cent. Of the remaining samples, 22% were below 0.16% acid and 20% contained in excess of 0.24% acid. Only 18% of the samples contained in excess 0.2 mg. of sediment per half pint sample. Overrun varied from 15 to 100%, with 60% of the samples having an overrun between 31 and 50%.

Twenty-four % of the samples had a plate count of less than 10,000 per ml.; 26% contained from 10,000-50,000 bacteria per ml.; 12% contained from 51,000-100,000 bacteria per ml., 8% contained from 101,000-1,000,000 bacteria per ml., and the remaining 30 per cent of the samples contained in excess of 1,000,000 bacteria per ml. Thirty-six % of the samples contained in excess of 10 coliform bacteria per ml.

Time and temperature of storage of the mix, and inadequate cleaning and sanitizing of the equipment were responsible for the high bacterial counts observed.

All of the samples of ice milk were found to be properly pasteurized. W. J. Caulfield

68. Existing composition laws pertaining to plain ice cream. J. A. MEISER, K. T. SCOTT, and P. S. LUCAS, Mich. Agr. Expt. Sta., East Lansing. Ice Cream Rev., **38**, 3: 184. 1954.

A review of the state standards pertaining to ice cream is presented. All states have established a min. butterfat percentage for ice cream which varies from 8 to 14%. Twenty-three states have established min. standards of 18% to 20% for total milk solids in ice cream. Six additional states require a min. of 26% to 37% total solids and two states require min. food solids of 33% and 36% respectively.

In all but 11 states some type of regulation is in effect governing the amount of overrun in ice cream. Overrun regulations include min. food solids, min. weights, or a max. overrun. In 20 states two or more regulations govern the overrun which may be legally incorporated into ice cream.

The existing ice cream standards indicate that there is a marked lack of agreement between the different states as to the type of regulation which should be adopted. The authors point out that standards pertaining to milk solids and food solids have little value since procedures for determining the amount of these solids present are too costly and cumbersome for use by a control agency. It was observed that multiple standards imposed to limit overrun ferquently vary in their rigidity and lead to confusion.

In view of the multiplicity of laws regulating ice cream in the United States the authors feel that many existing state laws should be critically examined and changed as needed in the interests of simplification, brevity, clarity, and enforcibility. W. J. Caulfield

69. Pre-heater cuts cost of chocolate coating. ANON. Ice Cream Rev., **38**, 3: 106. 1954.

A cabinet with thermostatic control was built for $55 and has been used by the Langenfeld Ice Cream Co., of Watertown, S. D. to pre-heat chocolate bar coating to the proper dipping temperature. The use of this cabinet has reduced waste, and has resulted in a 10% increase in the number of bars produced per lb. of coating. The bars are more uniform and attractive as a result of using coating which is always at the correct dipping temperature.

W. J. Caulfield

MILK AND CREAM

70. Rancidity increasing? W. L. DUNKLEY and L. A. KELLY, Univ. of Cal., Davis. Milk Plant Monthly, **43**, 10: 24. 1954.

An increased incidence of rancid flavor has been encountered in Cal. in recent years. At least part of this increase appears attributable to more extensive use of pipeline milkers and farm tanks. Induced hydrolytic rancidity is most frequently encountered.

The agitator used in a farm tank may have a marked influence on the development of induced rancidity. Proper design depends on tank shape and operating conditions. Increasing the agitation in some tanks may reduce rancidity by increasing the rate of heat transfer, thereby decreasing the opportunity for temperature activation. Decreasing the agitator speed or size of the blades may reduce agitation activation in other tanks.

Limited experimental results indicate that air agitation tends to induce rancidity more than does mechanical agitation. More oxidized flavor has been encountered in milk produced with pipeline milkers than with bucket-type milking equipment. This increase of susceptibility to oxidized flavor does not appear to be related to increased aeration of the milk in the pipeline milker. A more logical explanation is that the milk comes in contact with more copper containing alloys. C. J. Babcock

71. Water-insoluble acids in cream. Ky. Agr. Expt. Sta., Lexington. 66th Ann. Rpt. 1953.

Tentative observations based on a very limited amount of data are: (1) no significant relationship between counts of the five types of microorganisms studied and the water-insoluble acids content of the cream, (2) there was no relationship between titratable acidity and water-insoluble acids content of the cream, (3) no specific flavor defects in cream was related to excessive water-insoluble acids content, (4) cream samples described as "clean" or "acid" usually had a low concentration of water-insoluble acids. R. W. Hunt

72. Winger's progress with sterile milk. T. D. Leathers. Milk Plant Monthly, **43**, 10: 36. 1954.

Whole milk, chocolate milk, ice cream mix, and cream, including half-and-half have been tested and successfully canned. The milk is handled the same as in a market milk plant until it leaves the separator or clarifier. After leaving the clarifier or separator, the milk goes into jacket-type pasteurizing vats where it is heated, hydrogen peroxide added, and held for 30 min. It is then cooled to 110° and catalase added to remove the hydrogen peroxide. This temperature is held for 15 min. before pasteurization and homogenization. The product then goes to a standard sealer or capping machine with a steam jet covering the top of the can as the lid is placed on. The sealed cans are heated to more than 250° F., held for 2½ to 3 min., and then cooled by a water spray to about 80° F.

It is reported that a cooked flavor in the milk is prevented by the "end-over-end" process in effect at all times while the milk is being heated and cooled in the sterilizer. The canned milk is reported to be non-perishable for at least 18 months. C. J. Babcock

73. Iodophores as preservatives for milk. C. K. Johns and I. Berzins, Canada Dept. of Agr., Ottawa, Ont. J. Milk and Food Technol., **17**, 10: 313. 1954.

The authors studied the effectiveness of a typical iodophor on bacteria normally associated with the dairy industry. They concluded that iodophores are not good preservatives in milk in concentrations which would escape detection by taste. H. H. Weiser

74. Centrifugation et teneur en bactéries du lait (The effect of centrifuging on the number of bacteria in milk). P. Simonart and G. Debeer. Neth. Milk & Dairy J., **8**: 101. 1954.

The experiments were conducted on a semi-industrial scale with an Alfa Laval centrifuge. The capacity ranged from 20-45 gal. per hr., with a centrifugal force ranging from 12,242-23,488 G. The forewarming temp. ranged from 13-71° C. Approximately 90-95% of the bacteria present in the milk could be removed by centrifugation at 15,000 G or more. The loss of total solids was negligible. In certain experiments the efficiency of separation decreased after extended running of the centrifuge which resulted in the removal of a smaller portion of the organisms. In two series of experiments the methylene blue test was used to check the quality of centrifuged milk after pasteurization (30 min. at 63° C.) and subsequent storage of this milk for 24 hr. at 25° C. Centrifugation of the milk improved its quality.

W. C. van der Zant

75. Means and method of filling cans with pressurized substances. E. W. Smith. U. S. Patent 2,693,418. 10 claims. Nov. 2, 1954. Official Gaz. U. S. Pat. Office, **688**, 1: 161. 1954.

Cans for holding cream under gas pressure for dispensing as whipped cream are first filled with an appropriate gas at about 75 psi, then cream is introduced under 100 psi pressure until the desired quantity of cream is contained in the can. The hole through which the gas and cream are introduced is then sealed.

R. Whitaker

76. Pasteurization without holding tubes. T. J. Hankinson, W. Litsky, R. B. Read, Jr., R. R. Brown, Univ. of Mass., Amherst. Milk Plant Monthly, **43**, 10: 39. 1954.

Preliminary experimental work shows that there is a possibility of a single standard for pasteurization, consisting only of minimum temperature of "come-up time." It is a process in which the lethal effect is expected to be contributed entirely by the heating period. The studies also show that the come-up time process may hold some promise in the commercial pasteurization of milk and if shown practical, would simplify our pasteurization procedures. Elimination of the holding time should make milk safer because the health agency needs to check only minimum temperatures. The elimination of the holding tube should reduce cost in the milk plant by reducing the initial cost of equipment, the installation costs, floor space requirements, and cleaning costs.

C. J. Babcock

77. Apparatus for separating butterfat from milk. V. O. Goument. U. S. Patent 2,694,520. 4 claims. Nov. 16, 1954. Official Gaz. U. S. Pat. Office, **688**, 3: 553. 1954.

A separator bowl is described which separates milk into skimmilk and cream and then washes the cream with water, finally discharging the butterfat suspended in water separate from the wash water containing the nonfat solids from the cream. R. Whitaker

78. Variaties in het citroenzuurgehalte van melk geleverd aan zuivelfabrieken in Friesland (Variations in citric acid content of milk delivered to dairies in Friesland). K. HOLWERDA. Neth. Milk & Dairy J., 8: 115. 1954.

The smallest citric acid contents were found in Nov., Dec., with a min. in Jan. Low values also were found during Feb. and March, but the mean value in March was not lower than in the following months. The decrease in citric acid content seemed related to the fact that the end of the lactation period of many cows in Friesland falls in this period. An increase in citric acid content was noted in Feb. when many cows are in the early part of their lactation period. W. C. van der Zant

NUTRITIVE VALUE OF DAIRY PRODUCTS

79. The vitamin B_6 content of milk products. J. B. HASSINEN, G. T. DURBIN, and F. W. BERNHART. J. Nutr., 53: 249. 1954.

The growth response of *S. carlsbergensis* was used to estimate the vitamin B_6 activity of fresh milk and of sterilized-liquid-milk products and of dried milk products made from the milk. The heating process used in sterilization of liquid-milk products causes a considerable decrease in the B_6 content. These decreases occur not only during the heating process but continue at a relatively rapid rate for as long as 7 d. afterward. Pyridoxine is more resistant to heat inactivation than pyridoxal, pyridoxamine, or the naturally occurring vitamin B_6 in milk. O. T. Stalleup

PHYSIOLOGY AND ENDOCRINOLOGY

80. Relationship between plasma vitamin A and liver vitamin A in calves fed a vitamin A depletion ration and calves fed minimum levels of vitamin A or carotene. J. E. ROUSSEAU, JR., C. M. DEMBICZAK, K. L. DOLGE, H. D. EATON, G. BEALL, and L. A. MOORE, Storrs Agr. Expt. Sta. and Univ. of Conn., Storrs, and Dairy Husb. Research Branch, USDA, Beltsville, Md. Presented at meeting of Eastern Div. A.D.S.A., Sept. 19, 1954.

A linear relationship between the logarithm of plasma vitamin A conc. and the logarithm of liver vitamin A conc. was found for 15 Guernsey and 43 Holstein calves fed a vitamin A depletion ration, and for 39 Holstein calves fed min. levels of vitamin A or carotene. The ave. age and wt. of the depletion group was 128 ± 19 d. and 263 ± 72 lb., and for the minimum levels group 200 ± 9 and 436 ± 48 lb. The regression equations with their standard errors of estimate were as follows: $\hat{Y} = +0.30 + 0.2964X \pm 0.10$ for the depletion group and $\hat{Y} = +0.50 + 0.2846X \pm 0.11$ for the min. levels group, where X and Y are the logarithms of the liver and plasma vitamin A conc. in γ% respectively. For a given conc. of liver vitamin A, the depletion group had a lower plasma vitamin A conc. than the group fed min. levels of vitamin A or carotene. For the prediction of liver conc. from plasma conc., the regressions of logarithm of liver conc. (X) on logarithm of plasma conc. (Y) gave: $\hat{X} = -0.02 + 2.3724Y \pm 0.28$ for the depletion group and $\hat{X} = -0.77 + 2.5336Y \pm 0.33$ for the min. levels group. These equations had applicable limits for prediction between approx. 4 and 26γ of vitamin A per 100 ml. of blood plasma.

Authors' Abstract

81. Congenital malformations as related to deficiencies of riboflavin and vitamin B_{12}, source of protein, calcium to phosphorus ratio and skeletal phosphorus metabolism. R. B. GRAINGER, B. L. O'DELL, and A. G. HOGAN. J. Nutr., 54, 1: 33. 1954.

Data are presented which indicate a high incidence of hydrocephalus, ocular defects, and skeletal abnormalities among the offspring of rat dams fed a diet known to be deficient in vitamin B_{12}, riboflavin, and possibly folic acid. The addition of these vitamins to a diet in which the dietary protein was of soybean origin gave almost complete protection. The omission of B_{12} resulted in hydrocephalus, eye defects, and increased incidence of bone defects. Omission of riboflavin was associated with increased skeletal abnormalities. The omission of both further increased skeletal defects. A high Ca: P ratio also increased skeletal defects. The alkaline phosphatase activity in the tibia of riboflavin and B_{12} deficient offspring and the rate of phosphorus deposition in the tibia of B_{12} depleted offspring were decreased as compared to normal. O. T. Stalleup

82. Effects of dietary calcium and phosphorus levels upon the physiological behavior of calcium and phosphorus in the rat. S. L. HANSARD and M. P. PLUMLEE. J. Nutr., 54, 1: 17. 1954.

Data are presented on the behavior of labeled Ca and P as a function of the dietary levels of these elements. Current Ca intake influenced endogenous losses less than did the Ca status of the animal at the time of measurement. Endogenous fecal Ca increased from 1 to 10 mg. per d. for rats maintained on low and high Ca diets respectively and true digestibility decreased with increased dietary Ca intake. Total absorption and retention of radioactive Ca were increased in rats with low Ca stores. Radioactive P was absorbed but subsequently excreted via the kidneys and less was retained. The behavior of Ca-45 retained by the tissues appears to be independent of the dietary Ca and P levels studied, except that Ca depleted animals demonstrated greater Ca-45 concentration and rate of turnover. Calcium maintenance requirements appears to be a function of the animals Ca status at the time of measurement. Balance

data appear to be basic for interpretation of the behavior of Ca-45 and P-32 in the animal body. O. T. Stallcup

83. Progesterone in functional infertility of cattle. F. M. L. Dawson, Min. of Agr. and Fisheries, Hadstock, Cambridge. Vet. Record, **66**, 23: 324. 1954.

Report is based upon a study of a Guernsey, a Jersey, and a Holstein herd over a 3-yr. period. Progesterone implants were made in 100 mg. doses from 3 to 5 d. after service. All heifers and cows treated had prolonged infertility histories. Forty-seven animals were treated and 36 conceived to first or second service. Eighteen untreated controls in the same herds were bred and 15 failed to conceive through 5 services. R. P. Niedermeier

84. Placental transfer of Mo^{99} and Ca^{45} in swine. R. L. Shirley, M. A. Jeter, J. P. Feaster, J. T. McCall, J. C. Cutler, and G. K. Davis. J. Nutr., **54**, 1: 59. 1954.

Radioactive molybdenum was readily absorbed after oral administration to sows and widely distributed in their tissues. Little or none was found in the tissues of the fetuses, indicating a placental barrier to this element. A high percentage of Ca-45 was found in the developing fetus and a greater percentage of it was found in the fetal bones per unit wt. than in the bones of the sows. O. T. Stallcup

85. The utilization of carotene by hypothyroid rats. L. Arnrich and A. F. Morgan. J. Nutr., **54**, 1: 107. 1954.

The conversion of carotene to vitamin A and the distribution of vitamin A were studied in young growing and mature rats made hypothyroid with thiouracil. The authors concluded that body wt. and growth rather than basal metabolic rate govern the utilization of vitamin A and that thyroid activity does not affect directly either absorption, transformation, or utilization of carotene. O. T. Stallcup

86. Serum inorganic sulfate sulfur as a measure of the sulfur intake of sheep. W. C. Weir and V. V. Rendig. J. Nutr., **54**, 1: 87. 1954.

The serum inorganic sulfur in sheep appears to vary with the sulfur intake of the animal. The administration of 3-gm. capsules of elemental sulfur twice daily to sheep fed this purified ration resulted in a rapid increase in serum sulfate. The usefulness of the blood serum sulfate test in detecting a low-sulfur intake in sheep is discussed. O. T. Stallcup

87. Au Sujet des Variations de la Teneur en Proteines, Vitamine C et Lactose, dans le Lait de Chevres Traitees avec "Helichrysum Italicum G. Don" (Variations of the Protein, Vitamin C, and Lactose Content in the Milk of Goats Treated with "Helichrysum Italicum G. Don"). A. Pino and B. Ferracute, Univ. of Camerino. Le Lait, **34**, 337: 369. 1954.

The authors have fed several preparations of *Helichrysum Italicum G. Don* to three lactating goats in an attempt to learn the mode of action of the drug. No significant change was noted in the level of daily milk production but during treatment intervals the protein and vitamin C content of the milk was elevated. Lactose content was depressed by the drug.

A. W. Rudnick, Jr.

SANITATION AND CLEANSING

88. Synthetic detergents. Ind. and Eng. Chem., **46**, 9: 1913. 1954.

This is the report of a symposium consisting of 9 papers by 19 authors on the production, properties, uses, and performance evaluation of different types of synthetic detergents.

B. H. Webb

89. Liquid metering mechanism in combination with container cleansing and sanitizing machines. R. W. Phillips, W. T. Phillips, and N. J. Schaack. U. S. Patent 2,694,402. 1 claim. Nov. 16, 1954. Official Gaz. U. S. Pat. Office, **688**, 3: 524. 1954.

An electrically controlled device for metering and timing the flow of cleaning solution to inverted cans in a milk can washer.

R. Whitaker

90. Big problem: dairy wastes. Striking solution: bio-oxidation. R. R. Kountz, Penn. State Univ., State College. Food Eng., **26**, 10: 89. 1954.

The main reason for unsatisfactory operation of many milk-waste treatment plants is inadequate supply of dissolved oxygen. The pilot plant designed at Penn State University and a similar facility in operation at Port Murray Dairy Co., Port Murray, N. J. employ a high velocity recirculation system that eliminates sludge and gives clear, low BOD effluent. Water ejectors designed for steam operation have been found highly effective for air dispersal and are non-clogging. Calculations for determining oxygen demand and plant size are given.

T. J. Claydon

91. Cleaned-in-place pipelines. R. F. Holland, Cornell Univ., Ithaca, N. Y. Food Eng., **26**, 10: 84. 1954.

In addition to recognized characteristics and advantages of present CIP lines, improvements are being made in fittings, and in sanitizing chemicals and procedures. Properly installed lines will contribute significant savings in labor and cleaning materials as well as in the cost of lines themselves. Lower bacterial counts in products and improved personnel relations are added advantages. T. J. Claydon

92. Effectiveness of cattle-rubbing devices and hand dusting for horn fly control. A. W. LINDQUIST and R. A. HOFFMAN, U.S.D.A., Agr. Research Adm., Bur. of Entomol. and Plant Quarantine. J. Econ. Entomol., **47**, 1: 79. 1954.

Field tests with cattle in Oregon were conducted to test two methods of horn fly control. One method of insecticide application was a device on which beef cattle rubbed themselves. It consisted of a 10 to 20 ft. cable with burlap bags wrapped around it, the devices being suspended between posts in locations frequented by cattle. A 5% concentration of either DDT or chlordane was made by diluting 25% emulsifiable solutions of the materials with fuel oil. The dilution was applied to wet the sacks thoroughly. Horn fly control for 30 to 70 d. was had with one application of insecticide to the rubbing device. Observations indicated no control of horse, deer, and stable flies, nor of mosquitoes. Pyrethrins plus piperonyl butoxide was considerably less effective.

In tests with dairy cattle, a small handful or heaping tablespoonful of 50% methoxychlor wettable powder was sprinkled on, and rubbed lightly onto the backs and sides of animals. This gave 3 wk. of horn fly control.

E. H. Fisher

93. Observations on fly control by sanitation. R. A. HOFFMAN, Entomol. Research Br., Agr. Research Serv., U.S.D.A. J. Econ. Entomol., **47**, 1: 194. 1954.

It was demonstrated by one dairy farmer that strict sanitation, plus one residual spraying of the milking parlor with a chlorinated hydrocarbon insecticide, plus daily spraying of the cows with pyrethrum at milking time can noticeably reduce the fly population. The observations were made in a California area of lower rainfall and humidity.

E. H. Fisher

94. The selective vestibule. E. M. SEARLS, C. WHITE, and T. E. MCLAUGHLIN. Milk Dealer, **44**, 1: 170. 1954.

It is now possible to keep flying insects and airborne debris out of food plants. The entrance of many of these undesirable materials may be prevented by the use of a selective vestibule which permits passage of personnel and materials, but simultaneously provides a static air space where flying or airborne objects are either destroyed chemically or permitted to precipitate from the atmosphere. It should be about 6 ft. wide by 12 ft. long inside dimensions. An absolute requisite for an effective vestibule is that the doors at one end or the other should be closed at all times. If the vestibule is to exclude flying insects, apparatus must be installed for filling the room with an insecticidal mist either periodically or at limited intervals when the outside door is opened. The description of such apparatus is given. Opening for conveyors can permit desired objects to pass through without the passage of the unwanted flying insects and debris by a fast-moving curtain of either air or water properly applied. The curtain of air being the most desirable.

C. J. Babcock

95. Effects on some insects of the blood and manure of cattle fed certain chlorinated hydrocarbon insecticides. G. W. EDDY, W. S. MCGREGOR, D. E. HOPKINS, and J. M. DREISS, Entomol. Research Branch, and R. D. RADELEFF, Animal and Poultry Husbandry Research Br., Agr. Res. Serv., U.S.D.A. J. Econ. Entomol., **47**, 1: 35. 1954.

Yearling Hereford cattle received feed to which was added various concentrations of insecticides in acetone solution. Lindane, BHC, dieldrin, aldrin, chlordane, and toxaphene were fed for various lengths of time. The effect of the blood and/or feces, of insecticide-fed animals, on several species of insects was studied.

Horn flies feeding on treated animals during the first 21 d. after treatment were effectively controlled by the 100 ppm lindane feed treatment. This treatment showed some effect against the bloodsucking stable flies and mosquitoes, and the manure was toxic to horn fly larvae.

Larvae of horn, house, and stable flies were affected by manure from cattle fed aldrin or dieldrin. Horn and housefly larvae were not affected by manure from an animal fed chlordane. Manure with toxaphene was not toxic to house fly larvae. Cattle grubs (larvae) were not affected by cattle fed aldrin, chlordane, dieldrin, or lindane.

E. H. Fisher

96. Tests with pyrethrum synergists combined with some organic phosphorus compounds against DDT-resistant flies. R. A. HOFFMAN, T. L. HOPKINS, and A. W. LINDQUIST, U.S.D.A. Agr. Res. Adm., Bur. of Entomol. and Plant Quarantine. J. Econ. Entomol., **47**, 1: 72. 1954.

Laboratory toxicity tests were conducted against DDT-resistant house flies, using each of 7 organic phosphorus compounds in combination with one of 19 candidate synergists.

Most pyrethrum synergists increased toxicity of certain phosphorus compounds; activity of a synergist was not the same with all the better phosphate combinations. The synergism increased initial toxicity and prolonged the effectiveness.

E. H. Fisher

97. Differences between a resistant and a non-resistant strain of the German cockroach. J. MCD. GRAYSON, Va. Agr. Expt. Sta., Blacksburg. J. Econ. Entomol., **47**, 2: 253. 1954.

Laboratory tests compared an insecticide-resistant strain of German cockroach from Texas with a non-resistant laboratory strain. The Texas strain was highly resistant to chlor-

dane, and much less so to lindane and TEPP. The resistant strain produced fewer nymphs per female and fewer nymphs per egg, and the egg cases were smaller than in the susceptible. The resistant strain males and females weighed less than those of the same sex in the other strain. E. H. Fisher

98. Resistance to insecticides as a factor influencing the biotic potential of the house fly. M. VARZANDEH, W. N. BRUCE, and G. C. DECKER. J. Econ. Entomol., **47**, 1: 129. 1954.

Laboratory studies on biotic potential were made with 4 strains of house flies having high resistance to one or more insecticides, and 3 strains with normal susceptibility. Results showed that the heritable factors expressed as egg production, pupal or adult weights, adult longevity, egg hatchability, and larval and pupal survival were independent of factors associated with resistance to insecticides.
E. H. Fisher

99. The synergistic action of sulfoxide in insecticide sprays and aerosols. J. H. FALES, O. F. BODENSTEIN, and R. H. NELSON, Entomol. Research Br., Agr. Research Serv., U.S.D.A. J. Econ. Entomol., **47**, 1: 27. 1954.

The synergistic actions of sulfoxide and piperonyl butoxide with pyrethrins and allethrin were compared against the house fly, two species of mosquitoes, and the American cockroach. Sprays were studied by the Peet-Grady method, and aerosols with a laboratory dispenser.

Sulfoxide was comparable with piperonyl butoxide as a synergist. Results with pyrethrins were better than with allethrin.
E. H. Fisher

100. Horn fly control with chlorinated insecticides. G. R. DEFOLIART, Univ. of Wyo., Laramie. J. Econ. Entomol., **47**, 2: 266. 1954.

In Wyoming, 64 herds of beef cattle, and 5 of dairy were treated for horn fly control. Wettable powder sprays of various insecticides were applied at 200 lb. pressure, and used at the rate of 1½ to 2½ qt. per topline of each animal. Weekly fly counts determined when herds averaged 25 or more flies per animal, the criterion for retreatment. Insecticides were used at various conc. Dairy herds were treated with either methoxychlor or Q-137.

Most effective results were with 0.5% and 1% DDT, and 0.5% CS-708; nearly 4 wk. of protection was had with each. They were better than the conc. used of dieldrin, heptachlor, Q-137, sulphoxide-pyrethrins, and toxaphene. Neither the addition of BHC to DDT, nor of fused bentonite sulfur to toxaphene or DDT extended the period of protection. There was no evidence of horn fly resistance to insecticide on herds treated during 7 of the past 8 yr.
E. H. Fisher

101. Organic phosphorus compounds as toxicants in house fly baits. J. B. GAHAN, H. G. WILSON, and W. C. MCDUFFIE, Entomol. Research Br., Agr. Research Serv., U.S.D.A. J. Econ. Entomol., **47**, 2: 335. 1954.

Laboratory and field studies were made with Bayer L 13/59, Diazinon, and malathion as baits against the house fly. The first 2 materials were more toxic in laboratory tests against DDT-resistant flies than malathion when used in aqueous solutions containing 10% of molasses. There were indications that the ready-to-use solutions could be used 2 to 4 wk. after preparation. Concentrations of malathion and of Bayer L 13/59 reduced bait attractiveness; diazinon was not used in these tests.

Field tests were run in Florida dairy barns. Bait was applied with a sprinkling can on floors and other fly resting sites. One to 3 gal. of bait was applied in 4- to 6-in. wide strips in each barn. Baits containing 0.1% of either Bayer L 13/59, Diazinon, or malathion in a water mixture containing 10% of attractant molasses or sugar were most effective; repeated applications were necessary. Baits of 0.05 or 0.1% of TEPP in a 10% molasses solution were less effective than most baits containing the other 3 toxicants.

A bait of 0.1% of malathion and 10% molasses in water was effective in a garbage-disposal area where some other insecticides had not been successful. E. H. Fisher

102. A method for the evaluation and retreatment of insecticide-treated cotton strings used for house fly control. R. C. BECHTEL and A. A. GRIGARICK, Univ. of Cal., Davis. J. Econ. Entomol., **47**, 2: 369. 1954.

Three-foot lengths of #16 cotton string were soaked in preparations containing 10% sugar and either malathion or Diazinon. These were attached at intervals of 2 ft. on beams in an animal barn. A tray system attached to the strings was used to collect dead flies. The average number of dead flies collected each 3 d. during the 36 d. trial was high. Either 5% malathion or Diazinon was sufficient. A system for retreating the strings was developed.
E. H. Fisher

103. Fly dispersal in a rural area near Savannah, Georgia. K. D. QUARTERMAN, J. W. KILPATRICK, and W. MATHIS, Communnicable Disease Center, Public Health Service, Savannah, Georgia. J. Econ. Entomol., **47**, 3: 413. 1954.

House flies and blow flies (mostly *Callitroga macellaria)* were trapped in rural areas of Georgia. The flies were marked with dyes and radioactive phosphorus and released at dusk on the same premises where trapped. There was one release point in one test and five in another.

In less than 1 d. after release, house flies

were recovered up to 5 miles from release points. Marked flies of both species were trapped 8 to 10 miles from release points. Flies congregated mostly where food and breeding sites were most suitable.

E. H. Fisher

104. Bait studies for fly control. G. S. Langford, W. T. Johnson, and W. C. Harding, Univ. of Md., College Park. J. Econ. Entomol., **47**, 3: 438. 1954.

Laboratory tests evaluated 27 chemicals for use in sugar baits against the house fly. Those showing promise were then evaluated in the field, mostly in dairy barns. Baits were chiefly applied with either a sprinkling can or a compressed air sprayer. Baits were sprinkled on concrete floors of barns; in barns with no concrete floors, spraying was done in window ledges, door jambs, stanchion pipes, ceiling beams, and similar locations. Three phosphates, malathion, Diazinon, and Bayer L 13/59 in sugar solutions, were effective and practical for barn use. Malathion baits were also effective in urban fly control against house and blow flies. CS-708 was best of the chlorinated hydrocarbons in field tests, but not comparable with the phosphates. E. H. Fisher

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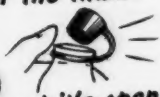

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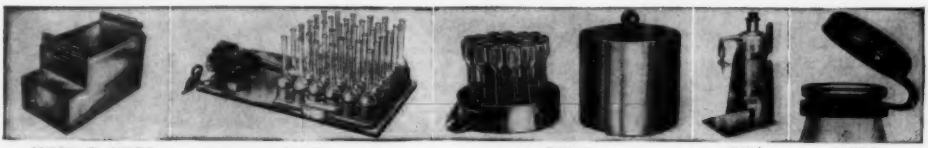

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